PROCEEDINGS

of the Thirteenth Annual

WESTERN FOREST INSECT WORK CONFERENCE

Tucson, Arizona

March 13-16, 1962

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Insect and Disease Control Branch
U. S. Forest Service
Pacific Northwest Region
Portland, Oregon

WESTERN FOREST INSECT WORK CONFERENCE, TUCSON, ARIZONA
March 13-16, 1962

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EXECUTIVE COMMITTEE (Thirteenth Conference)

B. H. Wilford, Fort Collins	-	Chairman
R. W. Stark, Berkeley	-	Immediate Past Chairman
A. E. Landgraf, Jr., Denver	-	Secretary-Treasurer
G. T. Silver, Victoria, B. C.	-	Councilor (1959)
G. R. Struble, Berkeley	-	Councilor (1960)
N. E. Johnson, Centralia	-	Councilor (1961)

C. L. Massey, Albuquerque - Program Chairman

EXECUTIVE COMMITTEE ELECT

K. H. Wright, Portland	-	Chairman
B. H. Wilford, Fort Collins	-	Immediate Past Chairman
P. W. Orr, Portland	-	Secretary-Treasurer
G. R. Struble, Berkeley	-	Councilor (1960)
N. E. Johnson, Centralia	-	Councilor (1961)
R. F. Shephard, Calgary	-	Councilor (1962)

N. E. Johnson, Centralia - 1963 Program Chairman

Prepared by the Secretary-Treasurer, P. W. Orr, from summaries submitted by Discussion Leaders. Stenographic services and duplication processing provided by the Insect and Disease Control Branch of the Division of Timber Management, U. S. Forest Service, Pacific Northwest Region.

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MINUTES OF THE INITIAL BUSINESS MEETING

March 13, 1962

The Chairman called the meeting to order at 9:45 a.m. in the Varsity Room at the Pioneer Hotel, Tucson, Arizona.

The following people were introduced:

Joseph Halperin, Israel	C. G. Thompson, Corvallis
Fred Schmidt, Portland	Bill Orr, Yosemite National Park
Ed Merkel, Flordia	Bob Thatcher, Nocogdoches
Dahl J. Kirkpatric, Albuquerque	Jack Coyne, Florida
W. F. Mendenhal, Arizona	Dr. C. W. Farstad, Ottawa
Bob Stevenson, Calgary	John Chansler, Albuquerque
Dick Pillmore, Denver	Tom Elliott, Albuquerque
Dave Crosby, Alaska	Al Lindstren, Arizona
Dr. Paul Baldwin, Fort Collins	Clyde Doran, Tucson
Pat Farrell, Tucson	F. F. Jewell, Mississippi

Department of Entomology, University of Arizona

Dr. H. E. Meyers	Dr. Floyd G. Werner
Dr. L. A. Carruth	Joseph C. Bequaert
Clarence E. Mickel	Martha L. Noller

Minutes of final business meeting as printed in the Twelfth annual proceedings were approved.

The Financial Statement was approved as read. Balance on hand as of March 12 was $176.04.

Reports of Standing Committees:

1. Education Committee - Chairman, Ron Stark; The Committee will meet in the Hotel Coffee Shop at noon Wednesday.

2. Common Names Committee - Chairman, Phil Johnson; The Committee will meet Tuesday evening at 7:30 in Room 903.

3. Ethical Practices Committee - Chairman, Ken Wright; Ken appointed the following assistants to aid him in selecting a new Chairman:

Pete Orr	Tom Koerber
Bill McCambridge	Dave Wood

4. Indexing of Unpublished Reports Committee - Chairman, Roy Shephard. Roy was unable to attend meeting. Bill Wilford read a progress report of status of indexing of reports at the various Stations.

The minutes of the Executive Committee were read:

A Nominating Committee was appointed to select candidates for Chairman, Secretary-Treasurer, and Councilor.

Members of the Nominating Committee are: Tom Silver, Ron Stark, and George Downing. Tom Silver was appointed Chairman.

The Executive Committee recommended that the 1963 meeting be held in the Portland area.

The Executive Committee recommended also that the Conference members select as program theme one of the following two suggestions:

1. Methodology and Research and Development.

2. Seminar - Where members present specific papers on the problems they are working on.

Meeting adjourned at 10:45 a.m.

INSECTS AFFECTING REGENERATION - THEME OF THE CONFERENCE

By

Charles A. Rindt
U. S. Forest Service
Washington, D. C.

I am honored to have been selected by you for this place on your program. It is a privilege to participate in your Conference and a welcome opportunity for me to broaden my acquaintance in the field of entomologist, particularly as it pertains to the big forest regeneration job at hand. The theme of the Conference is timely because of the current interest in forest regeneration as evidenced by the large programs being carried on by progressive timber companies, accomplishments on the many small forest ownerships and larger appropriations for reforestation of state and federal lands. The theme of the Conference is also evidence of the commendable close working relationships between silviculturists and entomologists in accomplishing forest regeneration objectives.

These objectives have broadened in the past few years to make the regeneration job more interesting and at the same time more complicated.

Timber values have increased to make the growing of timber a profitable economic venture where good management practices are allowed within predetermined cost limits. The Timber Resource Review projected timber use and timber growth into the future, showing the need for keeping forest land productive to supply timber and timber products to meet the growing demands of our rapidly growing population. Prompt and effective regeneration of commercial forest land is necessary to meet this growing demand.

The multiple use concept of forest management emphasizes the importance of forest management for purposes other than or in addition to timber production. These include recreation, water, wildlife, and range. All of them involve forest regeneration.

The ever growing network of highways and forest roads is bringing many more people into the forests. This has resulted in greater public interest in forest management and increased public pressures to re-establish trees on areas that have been logged, burned, or otherwise deforested.

Development of chemicals for insect control has made it practical and possible to control infestations. It is better practice, however, to prevent the critical situations from developing by good management than to depend on control of infestation. Public concern about the use of chemicals for control adds further stimulus to preventing the need for chemical control through good management practices or biologic control.

Machinery for ground preparation and tree planting and use of aircraft for seeding have made it possible to reforest areas that previously could not be considered; thereby expanding the work into new situations that can bring on new insect control problems.

Advancements in the field of forest tree genetics have demonstrated the possibilities and advantages of developing faster growing trees and trees of improved characteristics such as form, wood quality, adaptability to adverse sites, yield of gums and resins, etc. It has also demonstrated the possibility of developing trees that are more resistant to insect damage and that there is a danger of increasing susceptibility to insect damage through the same process; i.e., trees of good form developed through selection and cross breeding may be more susceptible to insect damage.

Tree improvement programs have already resulted in development of seed collection areas, seed orchards, and hybrids. It has generated a greater interest in awareness of the need for control of quality and origin of tree seed. Concentration of seed production on special areas and in cases to individual trees makes it necessary to get high yields of seed from them and to protect the crop from insect damage.

The forest regeneration job consists of two main parts. One is the reforestation of existing deforested and poorly stocked land. This is the area reported in the Timber Resource Review compiled from the nation-wide survey that was started in 1952. It is a job of rehabilitating land; of catching up on back work. Much of this area has been deforested for many years. The other is the reforestation of areas currently logged or burned by forest fire. It is a job of keeping abreast of the job and preventing further additions to the backlog area of deforested land.

A third job not generally classed as regeneration but related to it and of equal importance is cultural treatment of established reproduction and young growth. It must be released, weeded and thinned to put it into condition to grow and develop into productive forest stands.

I am going to quote a few figures for the purpose of illustrating the size of the regeneration job and to give some ideas of the area of reproduction and magnitude of related regeneration operations that are concerned with insect damage.

The Timber Resource Review shows 52 million acres of commercial forest land in need of planting. The word "planting" is used in the report, but it includes seeding and natural regeneration, whatever is the best method of re-establishing the forest. 8.6 million acres are in the Western States.

I was not able, from available records, to determine what acreage is logged each year; how much of it is classed as regeneration cut; how much reforests naturally or even how much of this currently logged and burned area is forested by planting and seeding. Regeneration accomplishment generally is not shown separately for the old deforested and the newly cutover and burned area, it is shown as one figure. We are going to keep these records for National Forest land.

Records do show that there were 5.2 million acres of planted forest stands in 1952 and there were 18.5 million acres in 1961. This is an increase of 13.2 million acres in the 9 years.

The annual rate of planting and seeding increased from 400,000 acres in 1952 to 1,800,000 acres in 1961. The increase is expected to continue at

a higher rate. While this is all listed as planting, it includes seeding. It does not include areas of natural reproduction. We can deduce from these figures that there are at least 13.2 million acres of planted and seeded reproduction and an additional large area, probably more than 13.2 million acres of natural reproduction less than 10 years old. Also that 2 or 3 million acres of reproduction is established each year by planting, seeding, and natural regeneration and that the annual accomplishment is going to continue to increase.

The 1.8 million acres of artificial reforestation accomplished in 1961 was made up of 181,000 acres of direct seeding and 1,619,000 acres of tree planting.

The tree planting program required the production of 1-1/2 billion trees in tree nurseries. About 200,000 pounds of tree seed were used to produce the nursery stock and something over 200,000 pounds for the direct seeding or a total of over 400,000 pounds of tree seed. The value of this seed at an average price of $7.00 per pound is $2,800,000. In a good seed year 3 or 4 times this amount would be harvested and stored for use in years of poor seed yield. The value of an annual tree seed harvest could amount to well over 10 million dollars. This is for domestic use. It does not include large quantities, perhaps an equal amount or more for export.

The value of the 1-1/2 billion trees produced in nurseries was probably close to 12 million dollars. The cost of the 1961 planting and seeding program was probably in the neighborhood of 60 million dollars. These figures serve to illustrate the size of the forest regeneration program; the large amount of money it is costing and something of its over-all value. Planting and seeding costs are only a part of the value. A small percentage damaged or killed by insects can amount to a large total loss. The figures serve another and perhaps more important purpose in emphasizing the insect damage potential on the large areas of even-aged, one-species reproduction which are usually established by planting or seeding and that are also established by planned regeneration cuts and cultural treatments. Insect problems are more likely to develop in such stands than in natural reproduction. By creating large areas of trees of the same species and the same stage of development we create conditions that are ideal for the spread of any insect that specializes on the species at any one stage of development. Planting on poor sites or on sites unsuited to a species creates conditions of poor thrift where weak trees may serve as infestation centers from which the damage spreads.

Many of the problems are of our own making. They can be prevented or minimized by applying what is already known about the insects and conditions that are favorable or unfavorable to them. This requires close cooperative working relationships between entomologists and silviculturists or forest managers in all stages of the regeneration program. This cooperative effort should go beyond recognition of insect damage and identification of the insects responsible for it. It should also go beyond surveys and reporting of conditions. It should include analysis of insect damage potentials on regeneration areas and the recommending of practices and cooperation in preparing operating prescriptions to prevent the trouble. Something can be learned from past work. Mistakes that were made in earlier work should not be repeated.

There is also need for more research in correlation of insect control and management and also a greater need for putting results of such research into practice. It is not enough to learn what can be done, the real purpose is to put the knowledge to use. This requires close cooperation between research and management in the formulation of research programs. Management has a responsibility for advising research of long range plans regarding regeneration programs and of promptly reporting problems encountered in carrying out programs and projects. Research can be of great help by designing research projects to meet the needs of management.

The over-all regeneration program involves or is concerned with production of tree seed, tree improvement through development of hybrids and development of seed orchards, operation of tree nurseries, direct seeding, tree planting, natural regeneration, and cultural treatment of the young stands including release, weeding and thinning. Insects must be considered in all of these operations.

I would like to specialize a little now and discuss some of the insect problems that are encountered in the various regeneration operations and what might be done in the way of control.

The first in order of sequence is seed.

Seed crops on most conifers are infrequent, therefore, it is necessary to harvest large quantities when the crop is good and to store the seed for use in years of low yield. Usually insect damage to seed and cones is lighter in years of heavy crop than in years of poor crop. There always has been some concern about seed losses or reduced crops caused by insects. Cone and seed insects have long been identified and described but until recently little effort has gone into control. Adequate practical control measures have not been developed.

New interest in cone and seed insects has been generated by the expanding regeneration program, particularly the success of direct seeding and the large quantities of seed needed and used for aerial seeding. There has also been some work that correlates success of natural regeneration with the amount of seed that falls on an area from seed trees or bordering timber stands.

I don't know of any studies that show the amount of tree seed that is destroyed by insects; perhaps such studies have been made. I know from experience that cone crops on certain species and on certain areas have been so heavily damaged by insects that they have not been worth harvesting. The value of a seed crop is not measured only in abundance of cones but in the amount of sound seed in the cones. It is conceivable that the volume of cone harvest could be cut in half in average years if insect damage could be controlled. It is not difficult to figure the many advantages of getting 1,000 pounds of Douglas-fir seed from 1,200 bushels of cones instead of 2,400 bushels. This is, of course, multiplied many times for the total amount of seed needed each year. Seed cost is the greatest factor in direct seeding project costs.

Hybrid seed and seed produced in seed orchards carries a high investment cost and a high value of purpose or use value. I have heard some estimates that hybrid pine seed costs as much as a dollar per seed and that they can be sold for that amount. Any loss of hybrid seed or seed produced in seed orchards has a serious effect on the regeneration program for which it was grown because substitute seed will not serve the same purpose and time will be lost in producing more seed; growth time is also lost.

It may not be possible to develop practical insect control methods for seed on natural stands. It should be possible and practical in seed orchards and seed collection areas. The physical problems connected with use of sprays and dusts for control can be overcome by selection of sites that are level enough for machinery to operate. Trees can be spaced to allow spray equipment to operate between them. The trees can be pruned back to maintain low bushy tops that are within easy range of the spray or dust materials. I believe there still is a job of working out spray schedules and perhaps also the most effective spray materials.

Biologic control may also be possible but it appears to be a long way off, particularly because there are so many kinds of insects that damage seeds and cones through the entire period of development from cone and pollen buds to maturity. I don't believe insect damage to seed in storage is a problem that is not now adequately controlled by cold temperature storage. Further investigation may be needed, however.

<u>Nurseries:</u> Insects have long been a recognized problem in forest tree nurseries. Various methods of control have been tried, some with poor success. One of my first experiences of that nature was with the use of arsenic on organic baits to control white grubs in nurseries in Wisconsin and Michigan. Others that I have personal knowledge of are strawberry root weevils in the Wind River Nursery in Washington and symphylids in the State nursery at Corvallis, Oregon. Recent developments of machines and techniques for applying soil sterilants to nursery soils has just about eliminated the nursery insect problem. It is an example of what can be done by cooperative effort of research and management.

Nematodes are at present causing question about otherwise desirable nursery sites in California. We do not know if, or to what extent, the nematodes will damage the trees or what success we will have in controlling them if they are injurious. We are also concerned about spreading them from the nursery to areas where the nursery-grown trees will be planted. While they are not insects, they present similar problems and the case of these California nurseries is typical of the problems with which we are concerned.

<u>Direct seeding:</u> This includes artificial seeding and natural seeding. It seems reasonable to suppose that natural seed and seedlings are subject to the same insect damage as seed and seedlings from artifical seeding operations. We were not so concerned about it until we began examining results of seeding operations.

I am afraid we still don't know very much about it. A research project concerning rodent damage to seed on direct seeding projects found that seeding failures grossly attributed to rodents had been principally caused

by other factors including insects. This particular study indicated that mice might be doing more good than harm because of the cut worms they destroyed. Heavy loss of seedlings is caused by cut worms on some areas; the extent of the damage is not fully known.

It appears probable too that insects destroy seed on the ground.

We need to know more about what happens to seed while it is on the ground and what happens to the newly germinated seedlings. We know that we sow 20,000 to 40,000 Douglas-fir seeds per acre with the objective of getting 600 or 700 trees. Nature usually sows much more. Seed loss has been popularly attributed to rodents and perhaps insects are a greater factor than we suppose.

Reproduction: There are many insects that damage or kill young trees in the seedling and reproduction stages of development. Some feed on roots; others feed on bark, foliage, buds, or cambium; others bore into the wood. Some of the most damaging insects are imported from other countries and find favorable conditions free of their native parasites and predators to keep them under control. The European pine shoot moth is an example of one import that damages pine reproduction. Special project control measures are needed to deal with these imported pests after they are established. Such control is costly, difficult, and usually only partially effective. The best control, of course, is to stop them from entering the country. It is also important to be on the alert to detect those that do get in so that control measures can be started while there is a chance to eradicate them.

Many insect pests are native and do not cause trouble in natural stands where nature maintains a balanced environment. They become troublesome when management practices create unnatural conditions. It is not always possible or practical to follow nature's way in establishing a new stand or to reconstruct the balanced conditions that existed in the original stand. The regenerating stand may have to be of different species or contain a heavier component of one species. Associated plants may have changed because of logging, fire or other causes. There may have been changes in site quality or management objectives.

These changed conditions complicate the job of planning and carrying out regeneration projects in such a way as to prevent insect damage by avoiding conditions that are favorable to population build-ups. An essential part of this job is to be able to recognize these favorable conditions and to know how and why they contribute to insect problems. In this connection, a distinction should be made between what is normal and what is abnormal insect damage. It may be good over-all management to learn to live with the normal and concentrate prevention and control efforts on the abnormal.

Although it may not be possible to reconstruct natural conditions on a regeneration project, there are certain preventative measures that can be followed. Entomologists can contribute to this type of control by taking part in preparing regeneration plans.

It is possible on many projects to plant or seed mixed species instead of a single species. This usually can be done with no more effort or at no

greater cost than using only one species. Cutting practices and cultural treatments can often be designed to favor a single species or a mixture of species.

Areas of poor site on regeneration areas can be left vacant of trees or reforested with selected species to eliminate the development of poor thrift trees. They are more susceptible to insect attack than thrifty trees and can become the nucleus of an infestation that can spread to the surrounding stand. An example is found in the Lake States where spittle bug populations build up on pine trees planted in frost pockets. Other examples are shallow soils on scabrock sites in the western pine regions.

South slopes can be planted or seeded to different species than north slopes. Species can be varied to conform with other site differences to obtain better thrift of all species. This can be done on small areas of different site within a regeneration project as well as on large areas of different site.

Density of reproduction can be varied according to site to prevent poor thrift that results from crowding. For example, draughty ponderosa pine sites will support fewer thrifty trees per acre than better sites in the same management unit. This variation in density can be accomplished at time of planting thereby reducing initial regeneration costs and making later thinning unnecessary. It is also an effective means of preventing poor thrift conditions that are favorable to insects and is a silvicultural method of control.

There is no precedent in nature for establishing pure stands of certain species, such as sugar pine. Species such as western hemlock and others can be pure in some locations but not in others. It is being done, however, and such practices may lead to trouble. It would be better to follow nature's lead and regenerate these species in mixtures until more is known about bringing them through to maturity in pure stands.

Some species such as eastern white pine and the spruces are subject to tip weevil and tip moth damage when grown in the open. This damage is minor or does not occur when the trees are carried through the reproduction stage in the shelter of an overstory. Too much shade from the overstory slows growth. Regeneration methods to obtain maximum growth and accomplish natural control of the insect pests should be developed by cooperation between entomologists and foresters in the preparation of project plans.

I want to mention, what appears to me, might be an opportunity to use insects to help regeneration. Competition from brush and other vegetation kills tree reproduction and retards growth. Release of reproduction has developed into a big and costly operation. I have observed very effective defoliation of ceanothus by insects and also the stripping of fire weed down to the bare stems. It appeared to me that there were literally millions of worms at work. They were accomplishing the release job for us. I wonder if it would be possible to culture these insects and transplant them to areas where we want them instead of leaving their occurance entirely to the whims of nature. I wonder also how much thought has gone into this possibility and perhaps other beneficial uses of insects related to regeneration.

In conclusion I want to recall to you the size of the regeneration job that lies ahead and its importance to the economy of the Nation. These things are set forth in detail in the "Report on the Timber Resources for America's Future" that summarizes the findings of the Timber Resource Review. The part of this regeneration job that is on the National Forests is summarized in the development program for the National Forests. Time objectives are stated for the National Forests program and good progress is being made toward their accomplishment.

It is more desirable and better forestry to prevent insect problems by planning regeneration programs and carrying out regeneration projects in such a manner that the problems do not develop. Public criticism of the use of chemicals emphasizes the desirability of biologic control.

To accomplish the regeneration job it is necessary for entomologists to understand the regeneration objectives of timber management and to be acquainted with regeneration practices and procedures that are commonly used--seed nursery, plantings, seeding, cultural treatments. It is necessary for foresters concerned with regeneration to understand the insect damage potentials that are created by various conditions that occur in nature or that are created by regeneration practices.

There should be close cooperation between foresters and entomologists in making plans for regeneration programs and in developing procedures to be followed on regeneration projects.

INSECTS AFFECTING FOREST REGENERATION - KEYNOTE SPEECH

By

M. L. Prebble
Chief, Forest Entomology & Pathology Branch
Canada Department of Forestry
Ottawa, Ontario

I am very grateful for the invitation from Calvin Massey, your Program Chairman, to take part in this Thirteenth Annual Meeting of the Western Forest Insect Work Conference. We in Canada have been much impressed with the accomplishments of this Conference since its inception in 1949. It could perhaps be taken for granted that the Conference would provide good reviews of insect problems extending from Alaska to Arizona and New Mexico. Beyond this, however, it has developed useful symposia on a variety of themes, including teaching of forest entomology, research needs and techniques, survey principles and practices, evaluation of insect damage, criteria for control decision, and problems relating to chemical and biological control. In addition, it has greatly increased the interest and value of the annual meeting by careful selection of meeting places, this one at Tucson being the most southerly and therefore particularly attractive to us from the North.

My interest in Tucson was prompted, ecologically, quite a long time ago. During the 1930's, I was assigned to studies of the European spruce sawfly in the central portion of the Gaspe Peninsula of Quebec, a region characterized by mountains, persistence of snow in the valleys until June, a short growing season, and abundant precipitation during the summer months. I was interested in the diapause phenomenon and environmental influences on the expression of the phenomenon throughout the range of the European spruce sawfly in eastern North America. In searching the literature on diapause and hibernation, I came upon the studies carried out by J. K. Breitenbecher at Tucson in 1911 and 1912. He was concerned with the water economy of the potato beetle, and its influence on dormancy. His results were published under the title "The relation of water to the behavior of the potato beetle in a desert" as part of a large monograph by W. L. Tower on "The mechanism of evolution in Leptinotarsa," Carnegie Institution of Washington, 1918. I remember being intrigued by Breitenbecher's tabulation of annual precipitation at Tucson, and contrasting the annual sum of 10 to 12 inches with the 21 inches of rainfall at our study centre in Gaspe, during July and August of 1939. Desiccation, as an ecological influence, seemed to be very exotic in relation to our own field experience.

This trip has been made especially memorable by the generosity of Raymond Price and Noel Wygant, of the Fort Collins Station, who so kindly arranged a 4-day trip, for my wife and myself, from Denver to Tucson by way of Durango and the Grand Canyon National Park, with numerous stops to see important forest insect problems of the region, and to enjoy its unique beauty.

Your Program Chairman implied that my remarks should be aimed in the

general direction of the theme of this Thirteenth Annual Conference, "Insects Affecting Forest Regeneration." I interpreted this theme to include any process involved in the establishment of young trees to replace the parent stand, or re-establishment of young trees to replace the parent stand, or re-establishment of trees even after prolonged withdrawal of the land from forest cover.

Among various approaches to this topic, I elected to review the subject in very broad outline, as it applies to Canada. This permits me to admit openly that I have no special knowledge of regeneration problems in the United States. And secondly, while some of my comments may apply in a general way to your country, it enables you to ignore, with charity for the speaker, those that do not.

Foresters in Canada have been concerned with regeneration problems for at least 35 to 40 years. Their initial efforts in this direction were to establish plantations of desired species, particularly white and red pine and to a lesser extent white spruce, on sand plains and abandoned farm lands, primarily in the earlier settled regions. Regeneration surveys, depending largely on the concept of stocked quadrats, have been employed as a guide to the adequacy of natural regeneration after fire or logging. Planting has been practiced widely in logged or logged-and-burned areas, where natural regeneration of the desired species was unsuccessful or too slow. During recent years, various cultural and operational techniques, such as scarification and strip cutting, have been used to improve regeneration of some of the more difficult species.

Apart from the relatively small proportion of forest land that is in private ownership, the commercial forests of Canada belong to, and are administered by, the Provinces. Until 10 years ago, there were no federal incentives to reforestation programs on provincial lands. Starting in 1951, federal financial assistance was made available to the provinces, under provisions of the Canada Forestry Act, a federal statute. Payments were made to the provinces on the basis of numbers of trees planted, and assistance was also provided for the establishment of new forest nurseries. During the last 10 years, the Federal Government provided $1.8 million in support of this program, resulting in some 125,000 acres of newly established plantations on provincial crown lands. Meanwhile, planting programs undertaken by industry and private owners are gradually being increased. The current rate of planting, by all agencies, is about 100,000 acres annually. The total national acreage of forest plantations is not recorded with exactness, but is probably between one and one and one-half million acres, with the largest acreages occurring in British Columbia, Ontario, and Quebec.

The total area of productive forest land exceeds 600 million acres. Of this total, about 200 million acres are classed as young growth stands, the result of natural regeneration following cutting, devastation of the parent stand by fire, insect outbreaks, windstorms, etc. This manifestation of successful natural regeneration outweighs the plantations by a ratio of approximately 160 to 1, on an area basis.

The national total of improved agricultural land is about 100 million acres. However, the census of 1956 confirmed that much of the agricul-

tural land is in fact sub-marginal. Twenty-one percent of some 575,000 farms produced less than $1,200 worth of produce annually, with the regional percentages rising much higher in the Atlantic Provinces and in British Columbia, where farm units are small. Arising out of this concern with sub-marginal and uneconomic farm lands, the Agricultural Rehabilitation and Development Act was enacted in 1961. This federal statute, patterned after rural development schemes already in operation in the United States, has one broad aim: to improve the economic position of farmers through elimination of problem areas where farm units are too small and productivity is too low. Among the means suggested to accomplish the purpose of this Act, the one of principal interest here is the proposal to find alternative uses for sub-marginal land. In eastern Canada, tree farming, farm woodlots and county forests are listed among alternative uses. In western Canada, conversion of marginal cropping lands to community pastures and to wildlife habitat areas has been suggested.

The total area of agricultural land that is classed as marginal is of the order of 20 million acres. In Ontario, alone, south of the Precambrian Shield, there are some 8 million acres of marginal or submarginal agricultural land. Until much more careful studies have been made by the Agricultural Rehabilitation and Development Administration, and the provincial and federal government departments associated with it in the rehabilitation program, it will be quite impossible to know what acreage of marginal farm lands may be converted to forest cover. However, if substantial progress is to be made, it seems more than likely that the current rate of plantation establishment will be increased several fold.

It is perhaps time now to come closer to the theme of this conference: insects affecting forest regeneration. Over 40 years ago the white pine weevil demonstrated its destructive potential in the new plantation of eastern white pine, most of which were established in the open, under habitat conditions most favorable to the weevil. Similar damage also appeared in plantations of Norway spruce, and to a lesser extent, in white spruce and red pine. On the west coast, its counterpart was the Sitka spruce weevil.

The European pine shoot moth has been a serious pest in extensive plantations of red and Scots pine in southern Ontario for over 35 years, and for a longer period in adjacent areas of the United States. The European pine sawfly has been of concern for over 20 years, and is gradually extending its range northward and eastward from its point of entry near Windsor and Detroit. In addition to these introduced pests of pine, several native species are perennially troublesome, namely the red-headed pine sawfly (*Neodiprion lecontei*), the red pine sawfly (*N. nanulus*), the pine rootcollar weevil (*Hylobius radicis*), the pales weevil, the pine weevil (*Pissodes approximatus*), and to a lesser extent the Saratoga spittlebug, the bark beetle *Ips pini*, and white grubs.

In contrast with the extended list of pine pests, very few have caused serious trouble in spruce plantations. The yellow-headed spruce sawfly, (*Pikonema alaskensis*), has from time to time caused local defoliation, especially in Quebec and the prairie provinces. Limited plantations of

Sitka spruce in British Columbia have been badly damaged by the Sitka spruce weevil. The extensive Douglas-fir plantations in British Columbia have been relatively free of serious insect problems.

There is no basic distinction between the insect pests of forest plantations and those that affect natural regeneration of the same tree species. However, the ecological circumstances are frequently quite different in the two habitats, and they tend to make plantations more susceptible to insect attack than areas of natural regeneration.

Much interest has been shown in cone and seed insects during recent years, and there is no question that they occasionally reduce the seed yield severely. This has been noted in recent studies in white spruce, red pine, and Douglas-fir. The importance of insect-caused seed losses will increase with the demand for greater quantities of field-collected seed to sustain enlarged reforestation programs. So far as I am aware, control of forest tree seed insects has not been attempted on an operational scale in Canada. Feasibility of control through cultural or chemical means will, I believe, be enhanced with the demand for seed of select origin, and especially if seed orchards of selected genetic strains are set up to supply special requirements.

I doubt that there are many instances where lack of seed is a major obstacle to successful natural regeneration in Canadian forests. Difficulties are occasionally experienced after very large fires, or after extensive clear-cutting of species that will not regenerate in their own shade; and in some species seed production is infrequent or sporadic. Furthermore, the effectiveness of the available supply may be limited by rodents, shrub competition, unfavorable seedbed, and too rigorous micro-environmental conditions. But, in general, seed supply is adequate despite the attacks of cone and seed insects, and the innumerable hazards that are encountered after seed fall.

Studies carried out in the boreal forest of northern Ontario yielded some figures of interest in this connection. In a mixed 70-year-old stand of aspen, balsam fir, white spruce and balsam poplar, the sub-dominant balsam fir had been producing flowers for 37 years. Based on the persistent cone spikes, whose date of origin is readily determined, it was estimated that 7.9 million balsam fir seeds per acre were produced during the flowering period, or about 213,000 seeds per acre per year. The regeneration stand at the time of study included 5,000 balsam fir seedlings per acre, or about 1 seedling for every 1,500 seeds produced. When the 37-year flowering period was divided into halves, it was found that one-quarter of the total seed production, occurring in the first half of the period, had yielded two-thirds of the total regeneration stand. Stated in another way, one seedling became established for every 650 seeds produced in the first period, and one seedling for every 2,900 seeds in the second period. Regeneration was, of course, more than adequate, and scarcity of favorable niches for seedling establishment evidently became limiting quite early in the long period of seed production.

This, of course, is not an unique observation, but is perhaps interesting only because of the reduction to quantitative terms. Similar results

could undoubtedly be demonstrated in many tree species, for example: spruce, hemlock, our Canadian pines, birch, maple--to mention a few that come readily to mind.

Even though one may doubt that cone and seed insects are a limiting factor in natural regeneration, this in no way detracts from the value of the studies being done on this group of insects; because there will be a need to know their biology and ecology in order to undertake effective control measures in situations where the highest possible yield of select seed is essential to reforestation programs.

We know very little about the insects affecting naturally established regeneration. Some of the tip weevils, shoot borers, and leaf-miners that build up to damaging populations in open-growing young stands appear to be much less abundant in regeneration stands that are sheltered by the parent overstory. What appears to be an interesting exception occurs in the relationships between the ambrosia beetle *Corthylus punctatissimus* and regeneration of sugar maple in southern Ontario. Fatal attacks on seedlings, up to about one-half inch in diameter at ground level, occur in the seedling stand under dense overstories. In a recent study, seedling mortality in one year reached 80 percent among seedlings that exceeded 100 stems per square yard under a dense canopy of mature sugar maple. The effect of removal of the larger seedlings, as they successively became large enough to support attacks of the ambrosia beetle, was comparable to the results produced by grazing. The field studies have not as yet been carried far enough to determine the role of the dense overstory in creating conditions favorable to large populations of the ambrosia beetle; or the role of the beetle in limiting growth and development of the surviving seedlings, once the overstory has been removed by felling or progressive decadence.

Up to 1950, our efforts on regeneration insects, in the broad sense here employed, amounted to not more than about 3 percent of our entomological resources. During the past 11 years the effort has gradually risen to about 10 percent. The majority of research officers working in this field are located in Ontario where the problems are particularly important because of the extensive use of the pines, and the occurrence of destructive introduced insects. Comparable work is also being done in British Columbia, and to a lesser extent in other regions of Canada.

The early effort on regeneration insects was directed essentially to life history studies, the nature and development of injury to the tree, and experimentation in chemical control. Biological control was attempted in the case of several introduced plantation pests, but the biological foundations for these attempts were not strong, nor were sufficiently intensive studies carried out after the introduction of biotic control agents, to give a satisfactory explanation of indifferent successes or apparent failures.

During the last decade, the studies have been intensified considerably to include the development of effective population sampling designs; the determination of population trends from year to year; and evalua-

tion of the influence of climatic factors, parasites, predators and diseases on population survival of pest species. Periodic examinations of plantations have been included among the duties of rangers in the Forest Insect Survey. Infestations of introduced pests have been followed with increasing care. The potentialities of biological control through the use of introduced parasites are being re-examined through more intensive and extensive studies at home, and through collaboration with the Commonwealth Institute of Biological Control in overseas countries. The possibility that some plantation pests of foreign origin are being transported with plantation stock from the forest nurseries is being investigated. Appropriate methods of fumigation are being developed in the event that it may be necessary to treat out-going shipments of seedlings, as a matter of routine.

Most of our studies of regeneration insects have been concerned with individual pest species, or the small number of species that inhabit such special micro-habitats as cones or shoots. This has probably not been an inappropriate method of approach to obtain, as rapidly as possible, intensive knowledge on the bionomics of the pest species. This method of approach seems also to be appropriate for short-term studies at any given stage of development of a plantation or of natural regeneration. However, the ecology of forest plantations may change progressively from a rather simple community on a sand plain, or sod-covered pasture, as the plantations become older and as additional plant and animal species enter the community. This enrichment of the ecosystem might be expected to increase the number of insect species feeding on the trees, while at the same time tending toward less severe fluctuations in abundance. A widely-known ecologist once asked me how many insect species would be needed in our plantations before we could feel secure. Of course, we do not know. But we do have one investigational program underway in pine plantations, where the object is to follow the development processes on a broad basis, including plants and animals, and to study the tree-feeding insects as a group rather than to concentrate on a particular species.

A somewhat comparable study is being undertaken in extensive regeneration studies of balsam fir, which succeeded parent stands killed by the spruce budworm about 15 years ago. Here the ultimate objective is to learn what regulates the endemic populations of the spruce budworm in regeneration stands. In the approach toward this objective, the investigator is concerned with populations of the various defoliating species on balsam fir and spruce, which defoliator species in the area serve as reservoirs for budworm parasites during periods of budworm scarcity; and the possibility that nest-provisioning wasps may provide an index to population numbers of the defoliating species.

Insect pest problems do not stand alone. Parasitic fungi, impoverished soils, susceptible exotic tree species, dangerously simple community structure, inappropriate cultural practices, and extremes in micro-environmental conditions are some of the factors, that singly or in combination, tend to compound the influence of insect pests, and particularly in the formative stages of forest plantations. A considerable amount of research is being done on pathogens affecting young trees, on nutrient requirements of forest tree seedlings, on the selection or development of resistant strains, on the ecology and silvicultural treatment of young

stands. But too infrequently are these factors studied concurrently with the investigation of the insect pests, and consequently to this extent our entomological studies, however admirable in themselves, do not make their full contribution to the comprehension of the whole problem. The same limitation applies equally, of course, to restricted studies of the other factors; for example, growth and yield studies without adequate regard for entomological and pathological history; tree selection and breeding for presumed resistance to insects and fungi without an intimate understanding of the mechanisms of resistance; and so on.

The implications of such unilateral or limited-subject approaches are quite far reaching. Biologically, we may learn a great deal about a particular pest species; but we may be less certain about the part that it really plays in development and survival of trees, because we have not included, in our plan of investigations, the possibility of interactions with other factors. This, in turn, limits our ability to reach general conclusions from specific study areas, no matter how carefully our entomological investigations have been carried out. I suppose it might also be added that management decisions, such as the need for control projects and cultural operations, must frequently be made intuitively, without the benefit of comprehensive analysis.

I expect that most of us tend to be embarrassed when a biological problem with which we are familiar tends to be greatly exaggerated by a non-specialist. On the other hand, what is our attitude when the biological problem is dismissed as non-consequential, or even scarcely recognized? A recently published economic treatise of over 130 pages, dealing with plantations of 3 valuable tree species in an important region of our country, contains less than 25 lines of text devoted to insect and disease problems. The short section which outlines the need for further research includes no mention of insects and diseases.

I mention this merely as an illustration of the severe limitations imposed by a unilateral, or limited-subject, approach to investigations of pests affecting forest regeneration. The entomological lore arising out of our researches is fascinating and has a wide currency among biologists, and also among some administrators and land managers who have a special interest in natural history. But we should not deceive ourselves: the application of the results of our research requires interpretation of effects of insect attack in terms of the resource to be managed, and preferably in terms that can be subjected to quantitative analysis. Through appropriate collaboration with other subject-matter specialists, and special efforts to understand the problems and needs of resource managers, I am confident that the applicability of the results of our research can be substantially improved, without lowering of its quality or lessening of the sense of dedication of the men who perform it.

REVIEW OF FOREST INSECT CONDITIONS
IN THE WESTERN UNITED STATES OF AMERICA
AND WESTERN PROVINCES OF CANADA - 1961

by

F. M. Yasinski
U. S. Forest Service
Albuquerque, New Mexico

Many species of insects were active throughout the forests of western North America in 1961. Reports from 7 U. S. Regions and 2 Canadian Provinces represented at this meeting list more than 60 different species of forest insects that caused noticeable amounts of damage during the past year.

Spruce Budworm: Most widespread of these pests was a defoliator--the spruce budworm. This defoliator was found in all sections of the West, except Alaska. Starting with British Columbia, the spruce budworm defoliated alpine fir, white spruce and Engelmann spruce on about 7.6 million acres. In Alberta, an acre-infested figure was not available but damage must be near the one-half million mark. Included in these estimates for the 2 Canadian Provinces are the 1-year and the 2-year cycle spruce budworm.

In the States spruce budworm infestations by acres with proposed control plans for 1962 are as follows:

Montana and Idaho (R-1)	- 4.5 million acres; control on about 450,000 acres
Idaho (R-4)	- 1.4 million acres; no control
Colorado (R-2)	- 1/2 million acres; control on about 50,000 acres
New Mexico (R-3)	- 1.1 million acres; control on about 430,000 acres

Principal hosts in these Regions are Douglas-fir and true firs.

Trend: Increasing throughout the West, except British Columbia, California, and Oregon.

Mountain Pine Beetle: Probably the biggest tree killer in 1961 was the Mountain pine beetle. The heaviest and most concentrated beetle-caused damage was in lodgepole pine in Utah, western Wyoming, and southern Idaho in Region 4. In this Region in 1961 there were 57 epidemic infestations reported, infesting over 600,000 trees. Ratio of 1961 to 1960 attacks was in the neighborhood of 10 to 1. On a large mountain pine control project in northern Utah, 167,000 trees were treated in 1961. An additional 252,000 trees are still infested in the project area.

Other infestations, smaller in size, were reported in British Columbia, Oregon, Washington, Idaho, and California. While the favorite host of this beetle in Region 4 was lodgepole pine, it was not necessarily so in other areas. In British Columbia the mountain pine beetle attacked and killed in addition to lodgepole pine, western white pine, and ponderosa pine. In Oregon, Washington, and Idaho aggressive infestations occurred largely in western white pine; in California, sugar and ponderosa pines; and in Wyoming, ponderosa and limber pines.

Trend: Increasing in Washington, Oregon, Utah, western Wyoming, and southern Idaho; static to decreasing in northern Idaho, Montana, central Wyoming. Trend not determined in British Columbia.

Douglas-fir Beetle: Another bark beetle that caused serious losses from British Columbia south to the Mexican Border was the Douglas-fir beetle. In the interior of British Columbia infestations of this beetle were numerous and widespread. In one area over 10 thousand infested trees were counted. As we continue southward into the western States, damage by this fir killer varied with the heaviest damage in southern Utah and northern Arizona.

Trend: Increasing in British Columbia, Utah, and Arizona. Static to decreasing in the other States.

(The following insects, though less widely distributed, were by no means less destructive.)

Larch Sawfly: In Alberta populations of the larch sawfly continued at a high level in 1961. In many areas in the northwestern part of the Province where serious defoliation of tamarack has occurred for several years, needle and shoot production was very sparse. In the States, 2 smaller infestations were reported--both in Idaho.

Trend: Increasing.

Western Pine Beetle: Infestations of this beetle were reported in the coastal States of Washington, Oregon and California. Losses in California were in ponderosa pine and Coulter pine. In Washington and Oregon losses were in ponderosa pine. Usually the western pine beetle attacks were combined with ips that top-killed the trees. In Sequoia National Park in California losses were the heaviest on record. An aggressive sanitation-salvage program has been started in many of the areas to control the beetle.

Trend: Decreasing in Washington; increasing in California and Oregon.

Fir Engraver: This bark beetle attacked various species of fir from the northern States of Washington and Montana south to the States bordering Mexico. California was hardest hit. In this State the fir engraver killed a greater volume of timber during the past year than any other forest insect. Early reports reveal that this outbreak is probably the biggest fir engraver infestation on record for California.

Damage to white and red fir is State-wide. In other States, hosts in addition to white fir were Grand and subalpine fir.

Trend: General increase throughout the western States.

Engelmann Spruce Beetle: Most of the damage caused by this beetle to Engelmann spruce is centered around the central and southern Rocky Mountain States of Wyoming, Colorado and New Mexico. Attempts to suppress the infestations rely mostly on logging the infested trees and supplementing this with treatment of the resulting slash. Another control measure, used in conjunction with control by logging, is the trap tree program. This method was used on the San Juan National Forest in Colorado, where a large scale trap tree program reduced a standing infestation from 6 trees per acre in 1960 to 1 tree per acre in 1961.

Trend: Increasing in Wyoming, Colorado, and New Mexico

Ips: Various species of ips caused limited amounts of damage in 1961. Those most important were the Oregon pine engraver and the 6-spined ips. California reported ips outbreaks in Coulter, Jeffrey and ponderosa pines. Idaho and Montana reported ips outbreaks in lodgepole pine and ponderosa pine, and South Dakota reported ips outbreaks in ponderosa pine.

Trend: General increase in all areas.

Pine Needle Tier: This insect was reported causing considerable damage in a 350 square mile area to Jack and lodgepole pine in northeastern Alberta. Prior to 1961 the only known outbreak of this insect occurred in Yellowstone National Park from 1921 to 1929.

Trend: Increasing.

Saddle-Backed Looper: In British Columbia about 10,500 acres of western hemlock, Amabilis fir, and white spruce were sprayed in 1961 to control this looper. About 1,500 acres outside of the spray area still are infested. Tree mortality was heavy. In some areas two-thirds of the basal area was killed; preliminary figures indicate that up to 10,000 board feet per acre was lost.

Trend: Downward.

Balsam Woolly Aphid: In British Columbia the balsam woolly aphid continues to spread near the City of Vancouver. Tree mortality continues: 8,300 dead Amabilis fir were counted in 1961 compared to 5,300 in 1960.

Predators are being released to suppress the population. Adults of a predator released in 1960 were found in 1961; this is the first indication that any of the introduced predators successfully survived the winter.

Infestations of the balsam woolly aphid in subalpine fir stands increased in size and intensity in Oregon (R-6). The largest and most severe outbreaks occurred on the Willamette National Forest. For the past 5 years,

efforts to establish colonies of foreign insect predators have been made with some success. Several species have become established and show some promise of reducing aphid populations.

Mortality in Pacific silver fir (Amabilis fir) and grand fir was at a very low level except in a few local areas.

Trend: In British Columbia tree mortality is expected to continue and the known range will probably increase. In Oregon a strong upward trend is apparent in subalpine fir--variable in Pacific silver fir and grand fir.

Forest Tent Caterpillar: Infestation of this defoliator of any size was reported only in the Canadian Provinces of British Columbia and Alberta. The largest area of infestation occurred in Alberta where an estimated 26,000 square miles of trembling aspen were moderately or severely defoliated during the past year.

Trend: Upward in both Provinces.

Lodgepole Needle Miner: This defoliator was reported in California, Idaho, and Wyoming. In California the largest infestation in the State is in Yosemite National Park where 60,000 acres are infested. In this area about 5,000 acres were aerially sprayed during the past year to combat this needle miner.

In Idaho and Wyoming (R-4) the current acreage of infestation is estimated at 200,000 acres--the same as last year.

Trend: Continuing epidemic in all three States.

Black-Headed Budworm: In 1961 this pest defoliated mainly western hemlock in Alaska and British Columbia; Pacific silver fir and hemlock in Washington.

Trend: Increasing in Alaska and British Columbia; undetermined in Washington.

Ponderosa Pine Needle Miner: This defoliator was severe on 19,000 acres of ponderosa pine in northern Utah. Another infestation of about 54,000 acres is active in Oregon.

Trend: Increasing.

Black Hills Beetle: This bark beetle continues to be a serious problem in ponderosa pine stands along the front ranges of Colorado, north Central Wyoming and in South Dakota. Over-all, various federal and private land managers plan to treat about 55,000 beetle infested pines in 1962.

Trend: Increasing.

European Pine Shoot Moth: This newcomer to the West was still confined to the port of entry States of Washington and Oregon.

In addition to known infestations in Seattle and Spokane, Washington and Portland, Oregon, shoot moth infestations were found in several more counties in both States in 1961. So far all infestations have been in nurseries or on ornamental pines. Fifteen species or varieties of pine in ornamental plantings are affected. Mugho and Scotch pine are the preferred hosts. All known infested trees in Spokane, Washington and Portland, Oregon were destroyed this past year. Quarantines have been established to prevent further movement of infested stock.

Trend: Still spreading, however, by movement of infested nursery stock.

Tube Moth (Argyrotaenia sp.): A tube moth infested about 100,000 of lodgepole pine near St. Anthony, Idaho (R-4). The infestation predominates in cutover areas.

Trend: Believed to be increasing.

Spruce Mealybug: Populations of a spruce mealybug continued at epidemic levels within Engelmann spruce stands in southern Utah. Infestations occur in 3 separate areas, totaling about 60,000 acres. Mortality of Engelmann spruce reproduction is noticeable within older infestations.

Trend: Slightly upward.

Jeffrey Pine Beetle: Localized area outbreaks of Jeffrey pine beetle were reported in northern, central, and southern California.

Trend: Slightly upward.

Roundheaded Pine Beetle: An infestation of this beetle in ponderosa pine occurred in southern New Mexico, after several years of inactivity. About 700 trees were sprayed in 1961 to suppress the beetle population.

Trend: Undetermined.

Silver Fir Beetle: Infestations of these beetles in Pacific silver fir increased slightly in Washington and Oregon. Damage remained well below the level experienced during the 1951-55 outbreaks.

Trend: Static.

Pine Sawflies: Two sawflies, Neodiprion, have seriously defoliated 6,000 acres of lodgepole and ponderosa pine in north central Montana since 1958. Evidence of a disease was noticed in population early in the summer of 1961. Overwintering egg population is very light.

Trend: Decreasing.

In Region 2 an unidentified sawfly lightly defoliated 400 acres of lodgepole pine near Grand Lake, Colorado.

Trend: Decreasing.

Hemlock Sawfly: This sawfly was found in light numbers over much of the black-headed budworm range around Frederick Sound in Alaska. Larval counts were down over last year.

Trend: Downard.

Western Hemlock Looper: After 10 years of absence this serious defoliator of western hemlock appeared near Astoria in western Oregon (R-6) this past year. Some mortality has already occurred in localized areas.

Trend: Believed to be upward.

Pine Butterfly: In British Columbia about 1,500 acres of infested Douglas-fir in lower Cameron River Valley were sprayed in June 1961. A helicopter applied the DDT in fuel oil at one-half pound per acre. An egg count showed a 97 percent decrease over 1960; this reduction was not wholly attributed to the spray. Egg counts at other points of rising populations on Vancouver Island also dropped greatly.

Trend: Downward.

Douglas-Fir Tussock Moth: Two species of tussock moth--one *Orgyia* genus and the other a *Hemerocampa*--fed on various conifers throughout the West in 1961.

In British Columbia *Orgyia* defoliated Douglas-fir, in Idaho it defoliated ponderosa pine, and in Nevada it defoliated white fir.

The *Hemerocampa* species was reported from Idaho, Colorado, and New Mexico.

In Idaho the hosts were Douglas-fir, spruce and grand fir. In Colorado - Douglas-fir, true firs, and blue spruce. In New Mexico - white and Douglas-fir.

In 1961 direct control was applied in Idaho to protect ponderosa pine seedlings in 2 plantations.

Trend: Increasing in British Columbia and Idaho; decreasing or static in Nevada, Colorado, and New Mexico.

Green-Striped Forest Looper: The large population of this looper in western hemlock on the west coast of Vancouver Island collapsed in 1961. A fungus is believed responsible for most of the mortality.

Trend: Downward.

Pandora Moth: The Pandora moth is defoliating lodgepole pine and ponderosa pine along the Colorado-Wyoming boundary. Defoliation ranged from light to severe on 36,000 acres.

Pandora moth populations are declining throughout most of the infested lodgepole pine in northern Utah. A native virus was responsible for the decrease over the 67,000-acre infestation.

Trend: Increasing along Colorado-Wyoming boundary; static to decreasing in Utah.

Great Basin Tent Caterpillar: In southern Colorado epidemic outbreak of this defoliator collapsed in 1960 due to virus and bacterial diseases. Only small patches of defoliated aspen were found in 1961.

In northern New Mexico, aspen on 100,000 acres was severely defoliated by this caterpillar. On the Navajo Indian Reservation infestations increased in 1962, after several years of downward trend.

Trend: Static in Colorado; continuing epidemic in New Mexico.

Larch Case Bearer: This insect is now present in intermittent larch stands in an area of about 9,000 square miles in northern Idaho and has invaded Montana. A Braconid parasite from the East was introduced in 1960 to combat the larch case bearers. More parasites are expected to be released in 1962.

Trend: Increasing.

Alaska Spruce Beetle: Heavy mortality of white spruce caused by this beetle continues in Alaska. Numerous local epidemics exist south of the Alaska range.

Trend: Continuing.

Spruce Budmoth: Outbreaks of light to moderate intensity of this moth occurred in young Sitka spruce stands at several locations on the Olympic Peninsula, Washington.

Trend: Undetermined.

Larch Looper: Aggressive outbreaks of this insect occurred along the Columbia River in Washington.

Trend: Undetermined.

Douglas-Fir Needle Midge: This insect is epidemic in Douglas-fir stands in northern Idaho and western Montana.

Trend: Increasing.

Larch Budmoth: About 500 acres of western larch are infested near Libby, Montana.

Trend: Increasing.

California Flatheaded Borer: California flatheaded borer continued to cause significant damage to Jeffrey and ponderosa pine in southern California.

Trend: Continuing at a high level.

Arizona Five-Spined Ips: Infestation of this ips in ponderosa pine declined sharply in southern Arizona. A fall examination, however, revealed that a high population of this ips exists in logging slash that could lead to a renewed outbreak in standing trees.

Trend: Undetermined.

Aspen Leaf Tier: An unidentified aspen leaf tier caused 75 to 100 percent defoliation on 2 areas of about 1,000 acres each in southern Utah. This is the first report of a leaf tier infestation of this magnitude in Region 4.

Trend: Static or possibly increasing.

Pinyon Needle Scale: In the southwest States of Arizona and New Mexico heavy scale populations continue on pinyon pine on Grand Canyon National Park and other lands administered by the National Park Service. Heavily infested needles drop prematurely, leaving only the current growth. Trees so weakened sometime fall prey to ips beetles.

In southwestern Utah and Nevada this defoliator is epidemic on 100,000 acres of pinyon pine, seriously curtailing the harvest of pinyon pine Christmas trees.

Trend: Increasing in Arizona and New Mexico and southern Colorado; static at a high level in southern Utah and Nevada.

Green Spruce Aphid: Defoliation of Sitka spruce by this aphid was exceptionally heavy in many coastal areas on Vancouver Island, British Columbia. In some areas mature trees and regeneration infested lost up to 90 percent of their foliage.

Trend: Uncertain. If the current outbreak follows the pattern of past infestations, the population should decrease.

Pine Reproduction Weevil: In California losses were serious in low-elevation ponderosa and Jeffrey pine plantations and in the natural regeneration ponderosa pine belts. Losses in natural stands are the highest on record.

Trend: Increasing.

Seed and Cone Insects: Only California reported anything in this category. In this State seed and cone insects took a heavy toll of the light to moderate crop on most commercial conifers. The sugar pine cone beetle almost completely destroyed a light cone crop on sugar pine. Cone moths, together with a midge heavily damaged a light crop of Douglas-fir cones. Seed chalcids and seed maggots nearly destroyed a light cone crop in white and red fir. Nearly all of the cones cross-pollinated in 1961 as a part of the Forest Service tree improvement program were destroyed by insects.

Trend: Generally increasing.

PANEL I - INSECT DAMAGE TO CONES, FLOWERS, AND SEEDS

March 13, 1:30 - 5:00 p.m.

Panel Moderator: K. H. Wright
Panelists: G. L. Downing, A. F. Hedlin
N. E. Johnson, T. W. Koerber,
R. W. Stark, F. C. Werner,
and E. P. Merkel

Moderator Wright opened the session by pointing out the rapidly increasing emphasis being placed by forest managers in the West on cone and seed insect problems. Reasons for the added emphasis are based on the strong effort being made by all forest land managing agencies to reforest land. In general, the need for control measures has developed faster than research has been able to provide answers. However, in recognition of the need, investigative programs on cone and seed insects have been started and accelerated in many parts of the West since 1950. The objectives of the panel were described as being to: (1) Discuss the scope of the problem, (2) the important insects involved, (3) status of our knowledge on biology and control, and (4) the research needs.

Mr. Wright expressed appreciation to E. P. Merkel of the Lake City, Florida, Laboratory of the Southeastern Forest Experiment Station for journeying west to join the panel. Mr. Merkel has been working intensively for several years on the insects damaging flowers, cones, and seeds of southern pines.

DAMAGE BY CONE AND SEED INSECTS IN WESTERN NORTH AMERICA

By

G. L. Downing
U. S. Forest Service
San Francisco, California

1. Showed slides depicting the 4 major types of cone and seed insect damage:

    a. Seed chalcids - feed within seeds.

    b. Cone beetles - cause cones to abort before seeds mature.

    c. Gall midges - cause galls on cone scales and seeds.

    d. Cone moths - feed on all parts of the developing cone.

2. History of cone and seed insect damage in western North America:

    Information on damage has been gathered primarily in conjunction with studies of the biology and habits of cone and seed insects. The first

efforts to determine damage in this field were by Miller, Keen, and Patterson from 1912 to 1917. Their work remains to this time as the most extensive assessment of damage by cone and seed insects in the West. Almost all of the other work in this field has been done since 1940 and most of this effort has been on pests of coastal Douglas-fir cones and seeds.

3. Impact of cone and seed insect damage on reforestation in western North America.

    a. Prevents or delays natural regeneration on cutover and burned lands.

    b. Cause delays and increases costs of seed collecting.

    c. Reduces the seed crop in seed production areas.

    d. Reduces the seed crop in seed orchards.

    e. Reduces the seed crop in tree breeding programs.

In 1952 there were 8.6 million acres of potential commercial forest land in need of reforestation in the western United States. In addition, large acreages are being cutover or burned annually, part of which require artificial reforestation. In California alone, present plans call for replanting 70,000 acres annually. Programs of this magnitude require large amounts of seed. Even a small percentage loss to insect pests can become a sizable figure when projected to include the total seed needed to support these large-scale planting and reseeding programs.

THE STATUS OF THE TAXONOMY OF THE INSECTS THAT DAMAGE CONES, FLOWERS, AND SEEDS OF FOREST TREES

By

F. G. Werner
Department of Entomology
University of Arizona
Tucson, Arizona

I want to preface my remarks by stating that I am speaking more as an insect taxonomist than as a forest entomologist. My point of view is likely to be somewhat influenced by my background.

To gain an idea of the state of the taxonomy of these insects I started first by looking up the papers cited by Keen in his excellent summary published in 1958. Then I checked the papers published since this summary. The results of this search are shown by the accompanying table, which includes only the most important groups. I was not surprised to find that there is a great deal of variation in the thoroughness of treatment of the various groups. Some have barely been touched, some treated

in isolated descriptions of individual species and others covered in thorough revisions of the groups involved. The immature stages are much more poorly known than the adults, as is the case with most insects.

The worker who is dealing with one of these species has several courses open to him in identifying it. If he has an adequate library available to him, he can go through the process of keying his sample out and comparing it with the descriptions and figures already published. This is likely to be a rather strenuous process, especially if he has the misfortune to be dealing with a group that has not been thoroughly worked out. In the process he learns the identifying characteristics of the species and can check further samples more readily. This is probably the ideal way of doing things.

The other main alternative is to send specimens from his sample to a taxonomist in one of the big centers and have him make the identification. The taxonomist has the advantage of a general familiarity with the group involved, perhaps a more thorough grasp of the literature, and other workers, probably including specimens identified by the men who wrote the taxonomic papers. In other words, he is in a better position to decide whether the specimens to be identified are the same as those previously reported than the man who has only the literature as a source.

The field workers should, however, be aware of several pitfalls in the use of the identifications provided by the taxonomist. The taxonomist has identified that sample with the information available at that time. Further work may show that the criteria available to him were not adequate. So the date of identification is of importance. The same man may very well identify the same sample as belonging to a different species when he has more refined taxonomic work to base his identification on. If the field man is not aware of the basis for identification, he may overlook similar species.

I submit that the field worker should make himself aware of the criteria used in identification. He should, in a way, become enough of a taxonomist himself that he can check the characteristics of the species he is working with. To do this he needs a source of information. With the expanded interest in research on cone and seed insects, I believe that one of the most useful tools for the identification of the insects will be a series of small manuals for each of the insect groups involved, in which the combination of characteristics that is typical of each species is pointed out and figured. The field worker should still rely heavily on the taxonomist for identification, but he should also refer to the manual before he applies the name the taxonomist has provided beyond the sample identified.

Such a series of manuals can obviously be worked out only when the taxonomy has been done in a group. The specialist who has worked with the individual group is probably in the best position to prepare it. But we do not have specialists for many of the groups of insects that affect seeds and cones. Yet I believe it is possible to fill in the gaps. Starting with specimens actually associated with cones and seeds, we need only to use all the resources we have available to get these identified and take the extra step of recording the basis for identification that has been used. Then

this information will be useful to others. The manual may not be the absolute last word, but it will provide a solid basis for identification that we can use until that last word is written.

Status of the taxonomy of the principal groups of cone- and seed-eating insects of conifers, 1962

	ADULT				IMMATURE STAGES				
	Key to Genus	Comparative Description of Species	Key to Species	Diagnostic Features Figured	Key to Genus	Comparative Description of Species	Key to Species	Diagnostic Features Figured	Principal References
Coleoptera:Scolytidae Conophthorus	X	X	X						Hopkins, 1915 (Ruckes, MS)
Diptera: Itonididae 9 genera	X	X		X		pt.	pt.		Pritchard, 1953 Foote, 1956 Tripp, 1955
Diptera: Lonchaeidae Earomyia	X	X	X	X					McAlpine, 1956
Hymenoptera:Torymidae Megastigmus	X	X	X						Milliron, 1949
Lepidoptera: Blasto-basidae:Holcocera		X		X					Heinrich, 1920
Geometridae: Eupithecia	X	X		X					McDunnough, 1949
Hyponomeutidae Argyresthia		X							Busck, 1916
Olethreutidae 5 genera	pt.	pt.	pt.		pt.	pt.	pt.		ad. Heinrich, 1920,23 l. MacKay, 1959
Phaloniidae Henricus									Keen, 1960
Phycitidae Dioryctria									Keen, 1960

RESEARCH ON CONE AND SEED INSECTS IN WESTERN CANADA

By

Alan Hedlin
Forest Entomology and Pathology Laboratory
Victoria, British Columbia

Some of the earliest work on cone and seed insects in western Canada was done in the 1930's by Mathers at Vancouver. His work consisted of general rearings for data on species of insects, their abundance and damage. In the early 1940's Prebble and Graham conducted studies on Vancouver Island. These involved investigations on insects and damage in growing and mature cones of several tree species. In the early 1950's Radcliffe conducted some investigations on seed losses in Douglas-fir on Vancouver Island. At the same time Ross at Vernon in the interior of British Columbia commenced studies which involved rearing and identifying insect species from a number of different trees. Trees which have received some attention at one time or another in British Columbia are western red cedar, hemlock, Sitka spruce, white spruce, Engelmann spruce, black spruce, grand fir, alpine fir, ponderosa pine, lodgepole pine, western larch, Rocky Mountain juniper, and Douglas-fir.

The studies presently in progress were started in 1957. As a result of information obtained from some exploratory studies carried out at this time and from earlier work mentioned above, emphasis was placed on the study of insects attacking Douglas-fir. Although Douglas-fir has received much attention because of serious seed losses caused by a number of insect species and because of the demand for its seed, this does not mean that other species are not suffering high losses also. Others have received less attention because current seed requirements are not as great as Douglas-fir. The studies being conducted have centered around biological investigations of the more serious insect species. In British Columbia there are 4 or 5 insects which are either consistently serious pests or are capable of becoming so and causing much damage. Of these, *Barbara colfaxiana* is by far the most important in the interior parts of the Province. In coastal areas *Contarinia oregonensis* is the most important species followed closely in some years by *C. washingtonensis*. *Megastigmus spermotrophus* and *Dioryctria abietivorella* are important seed destroyers in some years. In addition to studies on the biologies of some of these species, population studies are being conducted in relation to cone production in small permanent plots. Recently chemical control studies have been started also based on information obtained on biological studies.

I have been asked by our moderator to emphasize techniques used in carrying out biological studies and some of the problems encountered. Many of the techniques used in studying biologies of cone and seed insects can be applied generally to a number of different species from different host trees. Others are more specific in their application and are useful in studying certain phases in the development of particular insects.

I propose to mention some of the techniques having a specialized application and then discuss some of the problems encountered in these studies. Following that if time allows I will discuss other techniques which have a more general application.

Special techniques:

1. X-rays for studying seeds, cocoons.

2. CO_2 used to anaesthetize lepidopterous larvae - facilitates head capsule measurements throughout development of individuals.

3. Clearing and mounting micro specimens (midges) - facilitates head cap measurements and study of larval development on group basis. Use chloral hydrate clearing solution; mount in Hoyer's mounting medium.

4. Allowing midge larvae to spin cocoons in cotton batting for ease in handling and rearing under different conditions.

5. Examining eye-buds of midge prepupae for forecast of emergence and diapause numbers.

6. Trapping larvae below tree crowns during autumn emergence from cones.

7. Isolating cone-bearing twigs with fine-screen bags for data on oviposition periods; for confining a single species. Screen or dacron cloth are used.

Some problems:

1. Diapause - what factors influence this, and what effect has it on insect population fluctuations in relation to cone crop fluctuations?

2. Weather - how do variations and extremes affect insect development (i.e. emergence of *C. oregonensis* larvae from cones in fall).

3. How do insects locate flowers?

4. Flight habits - how far will insects fly in search of flowers?

General techniques:

1. In the laboratory and insectary:

   A. General rearings of mature cones for:

      (1) Species of insects, primary and parasitic.

      (2) Insect abundance.

      (3) Emergence period.

      (4) Sex ratio.

(5) Percentage emergence and diapause.

(6) Provides source of adult material for mating, oviposition, longevity studies.

B. Dissections of developing cones for:

(1) Egg development, incubation period, hatching period.

(2) Larval feeding habits, damage.

(3) Larval development - number and duration of instars, time of moulting, damage during each instar.

(4) Pupation - time, location.

(5) Parasites and their development in relation to host.

2. In the field:

A. Period of adult activity - (seasonal and daily).

B. Oviposition - habits for primary and parasitic insects.

C. Phenological development of host in relation to insect activities (when larvae emerge).

D. Emergence of insects from mature cones - stage of insect development, time of year, weather and its effect.

FACTORS AFFECTING THE ABUNDANCE OF CONE AND SEED INSECTS

By

Thomas W. Koerber
U. S. Forest Service
Pacific Southwest Forest & Range Experiment Station
Berkeley, California

Those who are engaged in the study of cone and seed insects have quickly come to realize that the abundance of these insects is controlled by the same forces which control the abundance of other insects and indeed all forms of animal life.

The weather, the food supply, parasites and predators, and various types of competition influence the size of cone and seed insect populations. The strength of these factors ranges from the most subtle influences and barely perceptible interactions through the naked ferocity of cannibalism to the catastrophic near eradication of populations by natural disasters.

As a group the cone and seed insects are well adjusted to the uncertainties of their way of life. Most of them seem to have the reproduction capacity

to take advantage of favorable circumstances and many resort to alternate hosts, or large-scale delayed emergence to survive natural disasters such as cone crop failures.

Those who have worked on cone and seed insects have necessarily taken samples of cones and examined them to find out something about the insects which attack them. Sampling to find out what insects are present or to determine the extent of the damage they have caused is relatively easy. Sampling to determine how many insects are on a tree is more difficult. When we consider the problem of determining the population of cone insects on an area basis, and the adaptations which permit the insects to survive natural disasters, making an estimate of the true population level becomes extremely difficult. Nevertheless, good population data is the key to the development of reliable control practices and as such should receive high priority in our research programs.

CHEMICAL CONTROL OF CONE AND SEED INSECTS IN THE SOUTHERN UNITED STATES

By

E. P. Merkel
U. S. Forest Service
Southeastern Forest Experiment Station
Lake City, Florida

The most destructive group of insects, affecting longleaf and slash pine seed production in the South are the three coneworms, *Dioryctria amatella*, *D. abietella*, and *D. clarioralis*. These species are capable of producing 3 or more generations a year. The occurrence of multiple generations, and the shifting of populations from one type of host food to another at different seasons of the year has made it difficult to trace the life history of each species. Despite these obstacles, my co-worker, Bern Ebel, has obtained considerable information on the habits of our common *Dioryctria* species. This will be published this year.

Two species of seed worms are common in the Deep South. *Laspeyresia ingens* infests the maturing cones of longleaf pine, and to a lesser degree, slash pine. The new species, *L. anaranjada*, shows a decided preference for slash pine cones.

A recently discovered pest of slash pine female flowers, *Gnophothrips piniphilus*, commonly kills 5 to 10 percent of the flower crop and thrips-caused mortality as high as 20 percent has been observed on individual trees. Studies are in progress to evaluate the effect of thrips-feeding on seed set and viability in female strobili which are only partially damaged and are able to continue their development.

The sawflies, *Xyela minor* and *X. bakeri*, have been reared in varying proportions from the male catkins of both slash and longleaf pines. *Xyela pini* has been found only on slash in our area. Dr. Burdick, Fresno State College, has been very helpful with our identifications and Ebel has supplied him with excellent series for clarification of the

identification of male specimens. We have developed a simple but fairly successful rearing method for Xyelids and hope to embark soon on a study of the effects of oviposition injury and larval feeding on pollen viability.

Itonidid or Cecidomyiid midges, presently being studied by Dr. Foote, at the National Museum, are very destructive to individual first- and second-year cones of slash and longleaf pines, but extensive damage has not been observed.

At least two Toumeyella scales have been found, particularly on the cone stalks of longleaf pine, but parasites and predators appear to be keeping the scale populations at a very low level.

Chemical Control of Gnophothrips piniphilus. In 1960 a preliminary field experiment was conducted with malathion, dieldrin, and heptachlor for slash pine thrips control. Control results were not conslusive with malathion and dieldrin and furthermore laboratory tests showed these two insecticides to be quite phytotoxic to pollen.

Last spring a randomized complete block experiment, using whole trees as blocks and tree-sectors as plots, was employed to test the effectiveness of a 0.1-percent heptachlor water emulsion applied with a garden-type, compressed-air sprayer. Two spray schedules were studied: (1) One application while flowers were in the twig-bud stage, and (2) two applications, i.e., when flowers were in the twig-bud stage and again just prior to pollination. Thrips attack averaged 31 percent in the checks, and 8 and 4 percent, respectively, for the one and two spray applications. The differences between the single and two spray applications were not significantly different.

Another study was conducted last year in cooperation with the Division of Forest Disease Research. In this study 11 trees, each paired with untreated checks, were sprayed with a hydraulic sprayer at weekly intervals with a fermate suspension for cone rust control. Heptachlor, at a 0.05-percent concentration, was mixed with the fermate and applied to flowers in the twig-bud stage and prior to pollination. The results look promising for both rust and thrips control but the effects of treatments on seed set and germination are still being evaluated.

Chemical Control of Laspeyresia anaranjada. Hydraulic sprayer applications of a 0.5-percent BHC and 0.5-percent DDT has failed to protect second-year slash pine cones. Individual cone spraying in 1960 with 0.1-percent Guthion water emulsion gave almost complete protection. Whole-tree applications of 0.2-percent Guthion gave near perfect control last year. A study will be installed this season to evaulate the possibility of a single hydraulic or mist blower application in May for seedworm control.

Although L. anaranjada usually destroys only about 5 percent of the viable slash pine seed, we feel that a spray program which controls this insect and the more destructive Dioryctria spp. as well, will help to maximize the seed yield of future seed orchards.

Chemical Control of *Dioryctria* spp. Coneworms: Research by Coyne at Gulfport, Mississippi showed that a 0.5-percent gamma BHC-water emulsion, applied either with hydraulic sprayer or mist blower, could protect cones of slash and longleaf pines from coneworm attack.

Although our research at Lake City, Florida has been somewhat repetitious with respect to spraying slash pine cones with BHC, I feel that the testing of these insecticides in different areas has tended to strengthen our spray recommendations and broaden their scope of application throughout the South.

Thirteen common insecticides were screened in the laboratory in 1959. Mature *D. abietella* larvae, reared by Ebel's published techniques, were fed fresh conelets which had been dipped in a series of concentrations of each insecticide and exposed to the treated food for 96 hours. The insecticides in decreasing order of toxicity to this insect were: endrin, gamma BHC, dieldrin, DDT, Guthion, aldrin, Diazinon, heptachlor, Sevin, toxaphene, Perthane, malathion, and chlordane.

Of the insecticides screened in the laboratory, BHC and Guthion have been field tested and shown to give good control of *Dioryctria* spp. DDT, even when applied monthly, protected first-year cones but not maturing slash pine cones. Possibly DDT was more effective against *D. clarioralis*, which is more common on first-year slash pine cones. It was hoped that other promising insecticides might be field tested this season, but due to the intense interest of the forest industry and tree breeders in mist blower and aerial spray applications, we will confine our 1962 studies to comparing mist blower applications of BHC, dieldrin, and Guthion with hydraulic spray applications.

At Lake City we have confined our field-spray experiments to slash pine, whereas Coyne has worked with both slash and longleaf pines. *Dioryctria* coneworms appear to be more destructive to longleaf pine shoots, flowers, and cones and are more common on this pine throughout the year. We have not found it necessary to apply sprays for *Dioryctria* control before April 1; whereas, Coyne has found early season spraying of longleaf pine to be necessary.

General Discussion: Our research efforts thus far have been directed toward developing insecticide spray schedules which will give the maximum protection and maximum seed yield to southern pine seed orchards. The problems of insect resistance and phytotoxicity, common in other orchard-grown crops, is a problem to which we must be alert. We are trying to develop a spray schedule which will reduce chemical applications to a minimum.

We have not lost sight of the possible use of systemic insecticides or biological and silvicultural control methods. It may be feasible in seed orchards to store seed surpluses for considerable periods of time in which case chemical control may not be necessary each year. Furthermore, depending on the isolation of seed orchards and the flight habits of the insects, it may be possible to spray orchards only every other year or less. The mechanical or chemical removal of the complete cone crop in

orchards for one or two consecutive years may reduce the build-up of heavy cone insect populations in seed orchards.

CONTROL OF CONE AND SEED INSECTS IN WESTERN UNITED STATES

By

Norman E. Johnson
Weyerhaeuser Forestry Research Center
Centralia, Washington

At the chance of sounding facetious, I will begin by saying that in the true sense of the word there have been no examples of cone and seed control and probably never will be. Our aim in the use of chemicals in this field is to protect a limited number of cones from ravages of insects so that we can get the necessary seed for reforesting our lands most economically. We have not and will not be using insecticides to control or regulate the almost infinite populations of the various species that exist in the vast forests of western United States. I note that the term "preventives" has been used recently. I would prefer "protectants." In any event we are protecting a product from insects and at the current time the use of chemicals holds the most promise.

A number of insecticides have been tested as protectants for cones against various insects and by several methods of application. I will not attempt to review all the work that has been done. The literature up to 1960 was reviewed at the ESA meeting in Spokane two years ago. With one exception, early sprayings by helicopter or airplane have been unsuccessful, whereas those by hand sprayers or various ground spraying equipment have shown some degree of success. Of the insecticides tested, guthion, an organic phosphate with an LD_{50} of about 18 mg/kg has consistently excelled against cone and seed insects of Douglas-fir. Sevin, Trithion, and Thimet have worked well also. DDT has shown some promise against Douglas-fir cone moth and Conophthorus in sugar pine. Of recent interest is the work done by Hedlin using systemic insecticides. He has demonstrated that Phosphamidon and Systox can be absorbed into Douglas-fir and translocated to young cones in concentrations that will kill larve of Contarinia oregonensis. Although my tests with these same insecticides have not been as encouraging, this approach holds much promise. Several new systemics are now available that have a much wider spectrum of activity than the older ones.

Other insecticide tests since the 1960 review include one by Wright in which he tested BHC and Sevin using a hydraulic sprayer. He was not able to demonstrate significant control of C. oregonensis with either of these two sprays. However, Sevin gave significant control of C. washingtonensis. Weyerhaeuser conducted a testusing Guthion wettable powder at several concentrations to determine the amount of insecticide necessary to control C. oregonensis. This study was preliminary to aerial tests planned this spring.

There is one thing I think bears repeating. We can definitely show the benefit of spraying cones. At current prices I can demonstrate several hundred percent return on money invested in successful cone and seed insect control.

Consider the following example:

THE CURRENT MARKET PRICE FOR DOUGLAS-FIR CONES:	$2.50-4.00/bu.
CURRENT COST OF TRANSPORTATION, PROCESSING, BUYING STATION	$5.00/bu.

NUMBER OF BUSHELS OF CONES TO YIELD ONE POUND SEED:

Count of 8-10 good seed per cone slice	1 bushel
Count of 4-5 good seed per cone slice	2 bushel
Count of 2-3 good seed per cone slice	3 bushel

COST OF ONE POUND OF SEED:

(8-10 sound seed)	Cost of 1 bu. cones.......	$4.00
	Cost of processing........	5.00
		$9.00
(4-5 sound seed)	Cost of 2 bu. cones.......	$6.00
	Cost of processing........	10.00
		$16.00
(2-3 sound seed)	Cost of 3 bu. cones.......	$7.50
	Cost of processing........	15.00
		$22.50

DIFFERENTIAL:

(2-3 vs. 8-10)	$22.50
	-9.00
	$11.50
(4-5 vs. 8-10)	$16.00
	-9.00
	$7.00
(2-3 vs. 4-5)	$22.50
	-16.00
	$6.50

The first question you may ask is why the low price of good cones. It would appear that cones with a high cut count should command 3 to 4 times the amount of those with low counts. However, during any one year and in any one locale, the cut count remains fairly constant. Seldom are you going to find trees with 8-10 counts right along side trees with 2-3 counts. The big decision is whether or not to collect cones at all that year. Pickers are at the mercy of the buyer and are usually glad to sell at any reasonable price.

Why the fluctuation in counts of good seed? There are three main reasons: (1) Insects, (2) lack of fertilization, and (3) lack of cones.

In some years 100 percent of the cones will be damaged in a given area. In other years the insects may be few and still the seed crop low because of poor fertilization. In other years no cones are collected because there are none. It costs only a small fraction of the savings cited to spray for the control of cone and seed insects. And it may even be worthwhile doing controlled pollination to increase the amount of seed per cone and thus reduce the cost of seed. Chemical fertilization of trees will help to increase cone yields. The big cost is still the number of bushels needed to make a pound of seed. Thus anything that can be done to reduce this cost will be worth considering. There are not many areas in forest entomology where the benefits from the use of chemicals are so clearly apparent.

STATUS OF RESEARCH ON WESTERN INSECTS DAMAGING TO CONES, FLOWERS, AND SEEDS

By

R. W. Stark
University of California
Berkeley, California

Studies on cone and seed insects at the University of California have been limited for the past year or so. Radiographic detection of infested seeds is now standard operating procedure. Seed is supplied by the seed collection agency of the California Division of Forestry at Davis, radiographed, the infested seed removed for rearing and the percent of apparently sound seed determined. This work has stimulated research by the Division of Timber Management for the State in determining whether accurate determination of seed viability can be made from x-ray spectrum.

Western-wide regional cooperative research in cone and seed insects has been proposed for several years, but as yet has not received financial support. Regional projects have been submitted for 7 state agricultural experiment stations and financing for 1962-63 is sincerely hoped for.

The objectives of the regional projects are:

1. To complete the inventory of the seed and cone insects and their natural enemies in the western states with special reference to their relative abundance and distribution.

2. To make systematic studies on the groups of seed and cone pests and to develop, refine and complete descriptions and keys to the species within the region, including mature and immature stages.

3. To develop adequate sampling methods for the insects attacking the more important tree species to provide:

    a. A basis for assigning relative levels of importance among the insect species.

b. A basis for future studies in population dynamics.

c. A standard basis for region-wide reporting where desired.

A total of 7 states have submitted contributing projects. Their specific program objectives are:

Arizona Experiment Station -- Floyd G. Werner.

"1. To establish an identification service for the western United States so that uniform identification of the insects obtained in the surveys and studies can be attained.

2. To develop, refine and complete descriptions and keys to species found in the region, including both mature and immature stages. In some groups taxonomic study will be necessary before regional keys can be prepared. As far as possible, this taxonomic work will be done in cooperation with the recognized specialist in the various groups.

3. Survey the principal coniferous species in Arizona, in selected areas, to determine the nature of the cone and seed fauna in this State."

California Experiment Station -- R. W. Stark.

"1. A survey of all insects attacking cones and seeds of forest trees in California, with their geographic distribution. In the past, many forest trees (e.g. redwood) have been neglected and this lack will be corrected.

2. To develop a method for assessing the damage done by the cone beetles *Conophthorus* (Coleoptera: Scolytidae), particularly the damage done by individuals. Present objectives include only *C. lambertianae* and *C. ponderosae.*

3. To develop a field sampling method for insects attacking pine, particularly *C. lambertianae* and *C. ponderosae.*"

Idaho Experiment Station -- John A. Schenk.

"1. To determine the identification, distribution and abundance of the insect species infesting cones and seeds of the forest conifers indigenous to Idaho.

2. To quantitatively determine the extent of damage attributable to those insect species of greatest importance."

New Mexico Experiment Station -- J. G. Watts.

"1. To establish the identity and distribution of insects attacking cones and seeds of forest trees in New Mexico.

2. To relate the seed and cone insect damage to the responsible species.

3. To develop a field technique to assess the extent of damage of cone and seed insects."

Oregon Experiment Station - J. A. Rudinsky.

"1. To survey the insects attacking cones and seeds of forest trees in Oregon, including their insect enemies, with the geographical distribution within the State.

2. To develop adequate methods for assessing the abundance and the damage done by the chalcid wasps (*Megastigmus*) particularly the species on true firs (*Abies amabilis*, *A. grandis*, *A. procera*, and *A. lasiocarpa*)."

Washington Experiment Station -- H. S. Telford.

"To determine:

(1) Which insect species are injurious to seeds and cones of forest trees in Washington.

(2) Their relative abundance and distribution.

(3) The identity and relative importance of naturally-occurring insect predators and parasites of seed and cone insects."

Wyoming Experiment Station -- Robert J. Lavigne.

"1. To survey the insects affecting the cones and seeds of forest trees in Wyoming and ascertain the distribution of these species within the State, thereby providing data which will increase our knowledge of the geographical distribution of these species in the western region.

2. To develop adequate sampling methods which can be used on a region-wide basis to determine the abundance and importance of the various species found to occur in Wyoming."

During 1961-62 Norman E. Johnson and Charles E. Schaefer completed their Ph.D. dissertations in cone and seed insects. Publication of both theses is anticipated; the titles are:

Johnson, N. E., *Contarinia washingtonensis* (Diptera: Cecidomyiidae) New species infesting Douglas-fir cones. *In press* Annals Ent. Soc. America.

Schaefer, C. E. 1962. The life history, development and distribution of the Monterey pine cone beetle. Ph.D. Thesis, University of California. (To be published as two separate papers.)

PANEL II - INSECT DAMAGE TO SEEDLINGS

March 14, 8:30 a.m. - 12:00 m.

Panel Moderator: W. F. McCambridge

Panelists: G. T. Silver	-	Scope of the problem in British Columbia and specific references to five problem species. Control cost philosophy was discussed.
C. E. Brown	-	Scope of the problem in Alberta with specific reference to seven insect enemies of seedlings.
P. O. Ritcher	-	Soil inhabiting insects attacking seedlings in the Pacific Northwest.
N. E. Johnson	-	Control cost philosophy in industry as related to seedling insects.
W. F. McCambridge and D. A. Pierce	-	Life history and control of the pinyon needle scale.

SCOPE OF THE PROBLEM (INSECT DAMAGE TO SEEDLINGS) IN BRITISH COLUMBIA

By

G. T. Silver
Forest Entomology and Pathology Laboratory
Victoria, British Columbia

Insects affecting seedlings in plantations and in the wild have been receiving more attention in recent years due to several reasons: (1) Heavy cutting of mature timber has resulted in ever-increasing acreages of regeneration, (2) the chance of serious insect and disease damage has increased as the area of regeneration increased, and (3) the practice of planting trees has increased. For example: 18,600 acres of new plantations were established in 1959. This is 10 percent of the area planted in all of the years up to 1959.

Because of the increasing number of insect problems in plantations and forest reproduction, we started compiling data on all insects collected by the Insect Survey in coastal British Columbia since 1949. The work will not be completed until spring 1963, but to date we have recorded 462 species of insects taken from plantations and reproduction (some of these trees are 50-60 feet tall and 40 years old. Of the 462 species, 90 species were found on seedlings in the following orders:

Order	Number of species
Lepidoptera	42
Coleoptera	27
Homoptera-Hemiptera	11
Diptera	4
Hymenoptera	2
Neuroptera	4

From the above listing, I would like to comment briefly on a few of our current problems.

Douglas-fir Terminal Damage, *Dioryctria* sp.: On plots examined in 1960 over 18 percent of the leaders on trees from 2 to 52 feet in height were broken, and 7.2 percent of the leaders had lost their buds.

The eggs of *Dioryctria* are laid in the growing terminals, and the larvae mine into the leader. Up to 16 galleries have been started in one leader, but only one gallery and one larva are able to survive. The galleries were always in the basal half of the current growth of the leaders and by fall were about 4 inches in length.

Spruce Gall Aphid, *Adelges cooleyi* (Gillett): In Douglas-fir 2-0 nursery stock, our records indicate mortality does not exceed 5 percent in the heaviest infestations. Heavy attacks do cause considerable stunting of growth.

On Sitka spruce, *A. cooleyi* damage is quite pronounced. A 29-year-old plantation on Vancouver Island was found in which 89 percent of the trees were infested. The growth was very poor, many were less than 10 feet high. Trees in the open were most heavily infested, and many are not expected to reach merchantable size. In this plantation the aphid has caused more damage than the spruce weevil.

Our present approach to the Adelges problem is one of prevention. The practice of planting Sitka spruce and Douglas-fir in alternate rows in plantations has been discouraged, as any protection which might be gained from the spruce weevil could be more than offset by heavy aphid infestations. Planting of Douglas-fir on the Queen Charlotte Islands has been forbidden by the B. C. Forest Service, and many Douglas-fir already planted have been located in case an eradication program may be necessary. The Queen Charlotte Islands are free from *A. cooleyi* at the present time.

Sitka Spruce Weevil, *Pissodes sitchensis* Hopkins: The Sitka spruce weevil is not a true seedling pest, but because attacks are present on some trees only 3-4 feet tall, I will make a few brief comments.

Logging companies have recently started to plant spruce and have shown a willingness to spend up to $15.00 an acre to protect plantations. Because of this interest, we have reactivated our weevil studies.

Re-examination of plots established in the late 1930's show: (1) There is a tendency for the weevils to attack the fastest growing trees; (2) some

trees sustain repeated attacks; (3) one or two attacks do not greatly affect tree form; (4) unweeviled trees at the end of 25 years were three times as tall as weeviled trees. As a result of these examinations, we recommend that spruce be planted at no more than 6 x 6-foot spacing.

Spruce trees on the west coast of Vancouver Island are relatively free from weevil attacks. One unweeviled stand examined, which was 38 years old, had dominant trees 93 feet tall and the average d.b.h. of all spruce was 12.8 inches. Natural regeneration also suffers only light weevil attack on the west coast. It is our belief that plantations established on the west coast of Vancouver Island will have a good chance of survival; conversely, unless companies are prepared to spend large sums on control, spruce plantations should not be established on the east coast of the island.

Sitka Spruce Terminal Damage, *Zeiraphera* spp.: Damage to Sitka spruce regeneration on the Queen Charlotte Islands has become a serious problem. From 1957 to 1960 tip damage increased until an average of 44 percent of the terminals over a large area were attacked, with damage running as high as 70 percent in some localities. The type of damage is variable as indicated below:

1. The terminal bud is killed before growth starts in the spring.

2. Terminal buds are attacked by up to 30 larvae which start mining the swelling bud beneath the bud cap.

3. Terminals develop normally in the spring and are then attacked by larvae which defoliate the needles then score the bark and finally end up as pith miners. The leader may have nearly completed its growth at this point.

4. Terminal and lateral buds are killed. These larvae are believed to be *Zeiraphera* sp., but it is not certain if they are the same species attacking the terminals. In 1961 when the insects attacking the terminals were mature larvae and pupae, those attacking the laterals were only first and second instar larvae.

A Weevil Damaging Douglas-fir Seedlings, *Plinthus carinatus* Boh: What appears to be a potentially serious problem was detected in a plantation at Kennedy Lake on Vancouver Island in 1961. Dead Douglas-fir seedlings were found to be girdled either above or just below the soil level. The damage has been attributed to a weevil tentatively identified as *Plinthus carinatus* Boh. It is believed that the weevils breed in freshly cut stumps, and the adults upon emerging feed by girdling the young seedlings.

Damage to date has not been excessive. Maximum damage was found to be 16-percent mortality due to girdling plus 20-percent partial girdling.

Philosophy of the Cost of Controlling Insects Affecting Seedlings: I was asked to deal very lightly with the economics of growing timber in British Columbia, particularly with whether or not the various costs of establishing a crop were carried on the books with interest to harvest

time. Six of nine questionnaires sent out to companies were returned. As all answers were fairly consistent, I feel the results are representative of British Columbia. The results are summarized as follows:

1. The cost of planting, thinning, and pruning (still experimental) and weed and brush control are considered as annual operating costs.

2. Insect control is also carried as an operating cost. All companies expressed a desire to protect plantations and regeneration from insect attack. The amount per acre varied, but on an average, the maximum amount of money per acre which they thought would be spent to protect plantations from serious damage was about equal to the cost of re-establishing plantations--about $15.00 per acre. (This sum would probably be the total amount per acre which might include more than one pest, from planting to harvest.) Major considerations to be appraised were: (1) The seriousness of the problem, (2) site, (3) value of the species, and (4) accessibility. On good sites with a valuable species, one company indicated it would go as high as $30.00 per acre, provided there was good assurance of success in the control operation. Another company is willing to spend up to the cost of establishing Sitka spruce plantations ($15.00 per acre) if there is a good chance that the control will result in a fully stocked stand; in this case, if 50 percent of the seedlings can be protected from damaging spruce weevil attacks.

An approach like this has given us a target to shoot for and studies are now underway to appraise the problem and see if such control is feasible.

SCOPE OF THE PROBLEM (INSECT DAMAGE TO SEEDLINGS) IN ALBERTA

By

C. E. Brown
Forest Entomology and Pathology Laboratory
Calgary, Alberta

In a forest economy concerned mainly with the utilization of virgin stands of mature timber, it is perhaps natural that seedlings have received little attention and the enemies of seedlings even less. This situation is now undergoing change. Areas under provincially supervised management plans for sustained yield have been and are being set up. These, along with leases to pulpwood companies who are interested in sustained yield, will generate new interest in seedlings and reproduction.

In natural stands remarkably little damage has been reported. In some instances this is unfortunate, as in many of our lodgepole pine stands where seedling mortality could be a blessing in helping to thin out the very dense reproduction which frequently occurs.

For the remainder of this presentation, I would like to mention a few of our troublesome insects affecting (a) very young seedlings--those in seed of transplant beds, and (b) larger-sized seedlings.

The only pest which has caused serious damage to seedlings in nurseries in the past few years is the spruce spider mite, Oligonychus unungius. This is the same mite which became so numerous in Montana following aerial sprayings with DDT. The mite has several generations a year, and consequently populations may build up rapidly. In seed and transplant beds, heavy mite infestations so reduce the vigor of seedlings that they must be left additional years in the beds to prevent high mortality once transplanted.

The pine needle scale, Phenacaspis pinifoliae Fitch, is another seedling growth retarder. With one generation per year, spread is slow and there is no evidence that the scale will become a serious pest in reforestation efforts.

The strawberry root weevil, Brachyrhinus ovatus (L) can be a very serious enemy of seedlings. One infestation was recorded where 200,000 seedlings were destroyed. Damage has been confined to nurseries, but in 1961 similar symptoms were observed in wildlings, and this situation must be investigated.

The spruce gall aphid, Adelges cooleyi (Gillett) is the insect most numerous on wild seedlings, but this aphid is most serious where Christmas trees are grown and on ornamental plantings. A race of the Cooley spruce gall aphid which completes its life cycle on spruce, never forming the gall stage, sometimes becomes very numerous on isolated small trees and causes serious damage.

Among the insects attacking seedlings, the terminal weevil, Pissodes sp., the pitch nodule makers, Petrova spp., and the root weevils, Hylobius spp., have received the most attention. Since the next panel will discuss Pissodes, I will go on to the pitch nodule makers.

Two species of pitch nodule makers, Petrova albicapitana and P. metallica, occur in Alberta. P. albicapitana is probably the most common, occurring on Jack and lodgeple pines. Larval feeding by this species on seedlings produces a large pitch mass on the main stem at the intersection of a whorl of lateral branches. This larval feeding so weakens the trees that the tops are broken off by wind or snow.

P. metallica, as far as we know, occurs in the Rocky Mountains and along the eastern slopes. The life history of this species is very similar to that of albicapitana. The nodule-making habits differ, however. The first-year nodule of metallica is more recognizable as a nodule than is that of albicapitana, which is simply a mass of silk and pitch. The second-year larvae do not move to the crotch of the branch but remain in the original nodule, enlarging it and excavating a long narrow chamber in the pitch.

In the heaviest infestations reported to date, 5 to 10 percent of the trees were attacked.

Hylobius root weevils - Hylobius warreni, the more common, and H. pinicola occur in Alberta. These weevils attack most species of coniferous trees, but in Alberta they are found predominantly on pine. It appears that this

insect prefers to attack the larger trees, although this cannot be proven. At present only 2 percent of seedling pine are being attacked.

It is feared that strip cutting of pine stands, the presently recommended harvest procedure, may greatly increase populations of these weevils. Such cutting will create ideal conditions for weevil development; namely, a reservoir of relatively uniform infestations now exists in the uncut strips, ideal habitat of thick humus in such strips, and adequate regeneration nearby--especially important for *H. warreni*, which has rudimentary wings. The forest economy of Alberta will probably develop as a pulpwood economy with relatively short cutting cycles. Under this condition *Hylobius* spp. and *Pissodes* spp. could be among our most serious forest pests.

SOIL-INHABITING INSECTS ATTACKING SEEDLINGS

By

P. O. Ritcher
Head, Department of Entomology
Oregon State University
Corvallis, Oregon

Less is known about soil-inhabiting forest insects than is known about any other group of forest insect pests.

Larvae of various scarabaeid beetles, commonly known as white grubs, have often been found causing damage to forest tree seedlings in various parts of the world. Damage is caused by cutting of the tap root, girdling the underground stem, or destruction of the feeder roots.

In the western United States there are several species attacking seedlings that are worthy of note.

1. *Polyphylla* spp. - Grubs of *Polyphylla* are frequently injurious to tree seedlings grown in sandy soils, especially in bottom lands, and under such conditions control of the grubs is highly recommended. One very common, widespread species is *P. decemlineata* (Say), whose adult is called the 10-lined June beetle.

   In September 1959 and in June 1960, R. L. Furniss observed white grub damage on small Douglas-fir trees in several Christmas tree plantations in Washington. These plantations are on sandy soils. In August 1961 *Polyphylla* grubs caused extensive damage in a 5-acre plantation of 3-year-old Douglas-fir seedlings near West Fir, Oregon. One-million nine-hundred thousand seedlings were destroyed. These seedlings were being hardened off by withholding water. Damage was spotty over the field but most severe on a ridge several hundred feet long and 30 to 40 feet wide. The grubs were mostly in the third instar.

2. Pleocoma spp. - The genus Pleocoma is widespread in Oregon and California, and their grubs are much more common in western forests than has been previously realized. Because of the fall flight habits of the adult--they fly at night in the rain--and the long larval life deep in the soil--9 to 13 years--most foresters are unaware of their existence and importance as root feeding pests.

Pleocoma simi Davis. In February 1960 rain beetle grub damage was observed on seedlings of Douglas-fir, ponderosa pine, sugar pine, and grand fir in seedling beds east of Roseburg, Oregon. Of those seedlings damaged, most were cut off 4 to 10 inches below the ground surface. Others were girdled or the smaller roots had been consumed. All evidence pointed to the damage being done during the winter months. Extent of damage was about 10 percent of the seedlings.

Other Pleocoma Work. Dave Fellin, graduate student at Oregon State, has been making a critical study of food habits of Pleocoma grubs in western Oregon. Grubs of P. dubitalis, P. simi, and P. carinata have been studied by periodic collection in forest soils and then sectioning their fore-guts to evaluate the ingested food. Much of their food has been found to be roots and rootlets of Douglas-fir.

CONTROL COST PHILOSOPHY IN INDUSTRY AS RELATED TO SEEDLING INSECTS

By

N. E. Johnson
Weyerhaeuser Company
Centralia, Washington

At the present time we are in the descriptive stage in the study of seedling insects. There is little reported in the literature on the affects of such insects on trees and even less on the stand as a whole. This information is needed before intelligent decisions can be made concerning the amount of money to be spent for insect protection. We are faced with spending today but harvesting many years in the future. As a reminder of the effect of compound interest on a long-term investment, consider an expenditure of $5 an acre at age 1 to combat Neodendron destructor. This amount placed in an alternative investment, say Gerber's Baby Food Company, would become $247.80 at the end of 80 years, the anticipated rotation age for Douglas-fir on Weyerhaeuser lands. Five percent was taken as the rate of interest in this case.

In attempting to calculate the amount of money which should be spent to control Neodendron destructor, it is necessary to categorize the damage the insect is capable of. N. destructor could: (1) Kill the stand, (2) kill part of the stand and cause understocking, (3) reduce growth, and (4) predispose the trees to other agents of destruction. If you knew enough about the insect to be pretty sure of the damage to except, control costs could be calculated.

According to Barnes et al (1954), the value of a young, unmerchantable stand is figured by:

$$Vm = (C + S + E)\ 1.op^{m} - (S+E) \quad \text{where}$$

Vm = value of stand at age m

m = age of stand when destroyed

C = cost of planting

S = value of soil

E = capitalized value of annual expenses (e/ .op where e = annual expenses)

1.op = 1 plus decimal expression of interest rate

If we assume C = \$25/acre, @ = \$25/acre, E = \$1/acre, and .op = 5 percent, then we can calculate the value of stands of various ages.

Age of stand -years-	Value -dollars-
2	32.21
4	40.12
6	48.80
8	58.46
10	69.03

Thus, if we have evidence that *N. destructor* will kill the stand we could afford the above amounts for protection in lieu of re-establishing the stand.

Where *N. destructor* kills part of the stand, distribution of the damage would be important. Concentrated killing would probably be more important than scattered killing. We must turn to the silviculturist for the effects of understocking on final yield. Grah's paper, "Effects of initial stocking on financial return from young growth Douglas-fir," is a big help in this respect. He used the following modes for his analysis.

Model	Initial stocking	Relationship to normal stocking	Number trees/acre
A	Full	100	571
B	Good	75	426
C	Fair	50	286
D	Poor	25	143

The above models were superimposed on sites 200, 170, and 140.

Grah found little difference in the yield between stands of poor and full initial stocking. Thus, it would appear that any money spent to control *N. destructor* would be wasted. Such is not the case. Partially stocked stands produce logs of many knots, large knots, and frequently too few rings per inch for certain products. Grah analyzed the effects of initial

stocking on financial return by comparing soil expectation values using the following:

$$Se = \frac{Y - C - e\left(\frac{(1+.op)^{r}-1}{.op}\right)}{(1+.op)^{r}-1}$$

where: Se = soil expectation value
Y = yield in terms of gross value of logs at rotation
C = cost of harvesting and marketing
e = annual expenses
r = length of rotation in years
.op = rate of interest charged expressed as a decimal (.03 as used here)

The soil expectation value for each site increases with age to a maximum and then decreases. The following table shows the difference between maximum soil expectation values for each model.

Stand model	Site 200	170	140
A	0	0	0
B	18	0	1
C	24	2	4
D	44	11	9

In Grah's words, "The net effect of managing stands on site 200 with one-fourth stocking is to reduce the worth of the enterprise by \$44.00 an acre." Thus, at age 20 one could afford to spend \$44.00 on site 200 that was one-quarter stocked to bring it to full stocking. If the cause for understocking occurred at say, age 5, the \$44.00 would be discounted 15 years to a value of about \$22.00 per acre.

Measurement of growth reduction caused by insect damage would be difficult at best. If it was established that <u>N. destructor</u> caused an effect equivalent to a 10-year growth reduction at rotation age, the difference in net income using Grah's data (site 200, rotation age 70) would be \$393.00. To determine the amount that could be spent to prevent this growth reduction, the \$393.00 would have to be discounted at an acceptable rate of interest from rotation to the time the damage occurred. If the damage all occurred at age 5, we could afford to spend \$16.50 per acre to prevent it. If it occurred at age 10, we could spent \$21.10 per acre.

Measurements of damage caused by insects predisposing trees to other agents would be difficult. That is, it would be difficult to segregate the importance of the insect from the other agents. However, the end result would be measured in terms of tree mortality, or effects from understocking, or reduction in growth.

We are all economic entomologists in a sense. It behooves us to make economic appraisals before and after every control operation we under-

take. It should be considered as much of an administrative and professional blunder to spend money when it is not needed as not to spend it when it is needed. It should be our professional obligation to save our employer's money (private or federal) even if we have to admit that _N. destructor_ really turns out to be _N. inquilinus_ or even _N. beneficialis._

LIFE HISTORY AND CONTROL OF THE PINYON NEEDLE SCALE

By

W. F. McCambridge
U. S. Forest Service
Rocky Mtn. Forest & Range Expt. Station
Fort Collins, Colorado

And

D. A. Pierce
U. S. Forest Service
Division of Timber Management
Denver, Colorado

The pinyon needle scale, _Matsucoccus acalyptus_ Herbert, infests all sizes of pinyon but is most frequently found attacking trees under 10 inches d.b.h. Because pinyon is so slow in becoming established, any insect which further delays or threatens this establishment presents a serious problem, perhaps out of proportion to its destructive power. The pinyon needle scale generally is a defoliator, but from time to time can kill all sizes of pinyon. Its affect on seedlings is generally to reduce growth and vigor.

The following life history was developed at the South Rim of Grand Canyon, Arizona.

During the latter half of April mated females lay oval clusters of yellow eggs held loosely together by thin white cottony strands of silky threads. The female will oviposit under bark scales anywhere on pinyon, but there are three main oviposition sites; viz. (1) around the root collar of the tree, (2) in the crotches of large branches, and (3) along the underside of large branches. As many as 125 eggs have been counted in one cluster. (Laboratory average found to be 68 with a range of 19 to 108.)

In about 4 weeks--the last of May--red eye spots become visible in the eggs, and in 7 to 10 days crawlers emerge. Upon emergence the crawlers are yellow. From the place of egg deposit the crawlers make their way out to the branches and settle on the needles produced the previous year. They generally align themselves with the head toward the base of the needle, insert the stylet into the paranchyma, become immobile, cover the body completely with wax and turn black. When crawlers are very numerous, they fill the previous year's growth, and excess scales will be forced to the apical half of the new foliage which is elongating from the bud. During June, July, and August the scale exists in the first instar. In

heavy infestations, as many as 133 first-instar scales have been counted on a two-needle pinyon fascicle that was approximately 3 centimeters long. When fully developed, the first instar is .44 mm. long and .12 mm. wide.

By late August or early September, second instar scales (the apodous stage) develop. This is accomplished by the second instar swelling and causing a longitudinal rupture along the mid-dorsum of the first-instar exuvium. The second instar develops directly over this divided exuvium. Feeding is rapid, and by October the second instar looks like a small black bean with maximum dimensions of 1.5 mm. in length and .70 mm. in width and thickness.

Those scales destined to become females will spend the winter in the second instar.

Third-instar males emerge from the apodous stage from mid-October through November and again in March. Extended warm periods during the winter may also foster this development. Emergence is accomplished by the third instar backing out of a rupture along the posterior dorsum. The male third instar is yellow and looks much like the first instar crawler in over-all shape and in the appearance of the antennae and legs. The third instar crawls down the tree from the needle on which it developed and selects a protected spot under a small pebble, twig, or in the litter, often as much as 12 feet or more from the tree on which it developed, spins a loose silken web, and molts to form a pupa. Males emerging in the fall go through the winter in the pupal stage. Many of the immature males emerging in March congregate at the base of the tree and go through the third instar and pupal stage in about a month's time.

About the first of April females begin to appear. They emerge from the apodous stage in the same manner as the male third instars, i.e. by backing out of an irregular rupture along the posterior dorsum. While so emerging, the majority of females are mated by males which also emerge in early April. In the process of emerging a female may be mated several times by several males appearing in rapid succession. Males die soon after copulating. Mated females than crawl to the oviposition sites, lay eggs, and die on the egg cluster. Laboratory tests have show that mating is necessary to produce viable eggs.

Experimental tests to control the pinyon needle scale on trees of seedling size have been very successful using either1-percent Dimethoate emulsion or 10-percent No. 2 fuel oil emulsion. Both materials were effective as ovacides applied when eye spots were visible in the eggs. Trees of this size have almost the total egg deposit around the root collar.

PANEL III - INSECT INJURY TO SAPLINGS

March 14, 1:30 - 5:00 p.m.

Panel Moderator: R. E. Stevenson
Panelists: W. K. Coulter, R. E. Stevens,
G. R. Struble, D. L. Wood,
and N. D. Wygant

EUROPEAN PINE SHOOT MOTH FUMIGATION STUDIES

By

W. K. Coulter
U. S. Forest Service
Pacific Northwest Forest & Range Expt. Station
Portland, Oregon

The Pacific Northwest Forest and Range Experiment Station in Portland, Oregon has been conducting studies on methods of eradicating the European pine shoot moth since December 1960. This foreign pest was discovered near Seattle, Washington in May 1959. It was later found in various localities in the Puget Sound area, and in isolated spots in Spokane and Portland.

Because this insect is a threat to plantations of native ponderosa pine in eastern Oregon and Washington, a crash program was undertaken to prevent further spread of the pest. The program consists of eradicating localized infestations by destruction and containment of other infestations by quarantine. Plans were to use fumigation, if a suitable method were developed, as a supplement or substitute for destruction. Studies of fumigation methods have not been completed but a major part of the field tests have been finished. It is the results of the field tests on methods that I want to present here today.

This insect pest is well known. Its distribution, habits, and the damage it causes is extensively covered in literature. This subject was also covered in part at last year's work conference.

The uses of methyl bromide as a fumigant are also well known to most of you. It was first used as an insecticide about 1919 and has been widely used for many years by quarantine workers to treat imported plant material. Therefore, much is known about methyl bromide, particularly regarding:

1. The operation of permanently installed fumigation chambers.

2. Plant tolerance to the gas depending on dormancy and the plant species, except for conifers.

3. Gas concentrations required to penetrate various commodities.

The field tests were aimed at developing techniques and equipment to apply to this particular control program. A technique was found that will give 100 percent control with no damage to many host species and only slight damage to most others. Equipment has been developed that is completely portable, allowing successful treatment with good efficiency for all growing conditions likely to be found.

The technique takes into account many variables effecting the insect and host but the concept that makes it work, i.e. to kill all of the insects without seriously damaging the host tree, is to adjust the length of treatment time according to changes in chamber temperature. Briefly the method for doing this is as follows:

1. Using changes in chamber temperature as an indicator of gas vapor pressure, regulate the length of treatment time to obtain the prescribed total treatment.

2. Divide treatment time into 30-minute periods.

3. From the average chamber temperature during each 30-minute period, calculate arbitrary vapor pressure units in the chamber.

4. Accumulate these "30-minute" units and adjust the length of the last period to obtain the treatment total.

The equipment that has been developed includes three basic chamber designs and safe, reliable gas introduction apparatus. The chambers include a 5-foot cylindrical chamber for small trees, 5-foot and 10-foot cubical chamber for larger trees, and a 25-foot long rectangular chamber for rows of trees up to seven feet in height. With these three basic types of chambers, practically any tree or group of trees can be treated efficiently regardless of its growing situation in a residential planting or in a commercial nursery.

Gas introduction apparatus has been designed for relatively precise control of the gas with a minimum of hazard to the operators.

In closing, it is appropriate to emphasize that this work has been a cooperative effort. Val Carolin, who represented the PNW Experiment Station, worked cooperatively with the Insect Control Section of NFA, Forest Service; the Pest Control Division, ARS.; and the Washington State Dept. of Natural Resources.

OTHER NATIVE TIP-MOTHS AND TIP-INFESTING INSECTS

By

George R. Struble
U. S. Forest Service
Pacific Southwest Forest & Range Expt. Station
Berkeley, California

This discussion is concerned primarily with <u>Rhyacionia pasadenana</u> and <u>R. zozana.</u> Brief mention is made on damage and distribution by an

unidentified tip moth in pinyon pine and the damage potential to saplings: mainly Petrova sp., Eucosma spp., Laspeyresia spp., Dioryctria, and representatives of three other insect groups - cone beetles, pine resin midge, and eurytomid wasps.

Confusion exists in identity of R. zozana and pasadenana, with evidence that hosts and distribution have influenced determinations rather than evidently obscure taxonomic differences. R. pasadenana is supposedly found in Monterey, bishop, and shore pine, and R. zozana in ponderosa and Jeffrey pine, mainly in California forests. Identities by ARS specialists of R. pasadenana from ponderosa and Jeffrey pine indicate a weak basis for separation and a need for study.

Damage by this insect(s) is severe periodically in both natural regeneration and plantations, especially ponderosa pine and Jeffrey pine. California records dating from 1929 report periodic severe damage to tips in localized areas, lasting for two or three seasons, and evidently controlled in this time by several parasitic insect enemies.

Aside from the pine resin midge, little is known still on the biology, extent of damage, or natural control of other insects potentially harmful to regeneration. Until now their damage significance has not been considered seriously. However, this is changing rapidly, along with increasing emphasis on planting and tree-breeding programs.

LIFE HISTORY AND HABITS OF THE LODGEPOLE PINE TERMINAL WEEVIL, PISSODES TERMINALIS HOPPING, IN CALIFORNIA

By

David L. Wood
Univeristy of California
Berkeley, California

Pissodes terminalis has long been recognized as one of the most injurious insect enemies of lodgepole pine regeneration in California. Larval feeding in the current year's terminals causes death of the leader resulting in secondary leader formation. At the juncture of the dead leader and the whorl of current year's laterals a deformed bole is produced, causing one or more laterals to compete for leadership. Saplings and poles have been observed to sustain attacks for 4 to 5 consecutive years, resulting in a bushy, multiple-branched top.

Initial investigations by R. W. Stark and D. L. Wood on the biology of this weevil in the Central Sierra Nevada Mountains of California indicate the following life history:

Mid-May - Adults were observed resting on the previous year's leader before current season's elongation had commenced.

Early June - Adults "in copulo" were collected from newly elongating leaders. Eggs are deposited singly in a feeding puncture at the base of the needles which are beginning to emerge from the fasicle sheath.

Mid-June - Larval feeding is confined primarily to the phloem-cambial region of the terminal leader proceeding in a spiral manner around the xylem.

Early July - A few larvae have penetrated the sapwood into the pith which generally occurs during the fourth instar.

Late July - Most larvae are feeding in the pith with a few pupae already present. The distal portion of the needles and the leader have begun to turn yellow with dessication and hardening of the stem evident.

Early Sept. - Larvae, pupae and adults are present in about equal numbers with many infested leaders completely faded except for the basal portion adjacent to the previous year's node.

Early Oct. - All infested tips have faded. Mature larvae, adults, and a small number of weevil exit holes were observed.

The distribution of *P. terminalis* was discussed in relation to the described geographic races of lodgepole pine and the natural *P. banksiana* X *P. contorta* var. *latifolia* hybrid which occurs in Alberta. The cytological investigations of Dr. S. G. Smith (Sault Ste. Marie Laboratory) in the genus *Pissodes* were also mentioned in relation to the distribution of this terminal weevil. The life history was compared and contrasted to *P. engelmanni*, *P. sitchensis*, and *P. strobi*. Studies will continue throughout the 1962 season.

THE PINE REPRODUCTION WEEVIL AND THE PINE NEEDLE-SHEATH MINER

By

R. E. Stevens
U. S. Forest Service
Pacific Southwest Forest & Range Expt. Station
Berkeley, California

Two of California's better known insect pests of young trees are the pine reproduction weevil, *Cylindrocopturus eatoni* Buchanan, and the pine needle-sheath miner, *Zelleria haimbachi* Busck. The former is a pest of young ponderosa and Jeffrey pines up to about 6 feet in height that are generally growing under unfavorable environmental factors. Insecticidal control has been used successfully in some instances, but a more attractive solution to the problem lies in the development of resistant trees. A Jeffrey x (Jeffrey x Coulter) hybrid has been very promising, and it is now being produced on a limited scale.

The pine needle-sheath miner can infest any of the hard pines, but in California is most commonly found on ponderosa and Jeffrey pines. It is not known as a tree killer, but has been shown to cause a moderate amount of growth reduction. Populations fluctuate over a wide scale, and heavy defoliation has not persisted over 2 or 3 years in any of the infestations that have been observed closely.

NOTES ON THE BIOLOGY OF THE ENGELMANN SPRUCE WEEVIL, PISSODES ENGELMANNI HOPKINS

By

R. E. Stevenson
Forest Entomology Laboratory
Calgary, Alberta

The Engelmann spruce weevil is a western species of the genus Pissodes Germar. The known range of the insect in western North America includes Alberta, British Columbia, the Northwest Territories, Idaho, and Montana. It causes damage to the leaders of young spruce. Permanent deformation occurs when the leader is killed and, with successive attacks, the trees become bush-like and commercially valueless. Similar damage is caused on eastern white pine by the white pine weevil, P. strobi (Peck) and on Sitka spruce by the Sitka spruce weevil, P. sitchensis Hopk.

The taxonomy of the genus is uncertain. In recent cytological work, Manna and Smith 1959 suggest that the three taxa, P. engelmanni, P. strobi, and P. sitchensis, may be one species. However, pending further taxonomic work the name P. engelmanni refers to the weevil on spruce in Alberta and adjacent regions. In Alberta and the Rocky Mountain Region the known hosts of the weevil are: western white, Engelmann, white, black, and Norway spruce.

The insect was found to be univoltine, overwintering as an adult at the bases of trees in which the larvae had fed the previous summer. In trees attacked the previous season current feeding and egg deposition occurred on the main stem below the old damage. On trees attacked the previous season, feeding and egg deposition occurred below either the first or second node. The eggs were deposited singly or in pairs in the feeding punctures. The larvae, upon hatching oriented themselves into a feeding ring in which they fed downward in cortical and phloem tissue leaving the outer bark intact. Pupation occurred in shallow chambers excavated by late instar larvae in the xylem of the leader. Adult weevils emerged from mid-August to early September.

A higher incidence of P. engelmanni occurred in pure stands of young spruce than in stands where an overstory either of pine or aspen-poplar occurred.

Eleven parasitic and predaceous insects have been found associated with the weevil. Of these, three parasitic hymenoptera were most common, Eurytoma pissodis Grlt. (Eurytomidae); Dolichomitus terebrans nubilipennis (Vier.) (Ichneumonidae); and Rhopalicus pulchripennis (Craw.) (Chalcididae). One diptera, Lonchaea sp. (Lonchaeidae), was a predator. Only E. pissodis was common to all infested areas.

Bird predation, often suspected as being important in reducing populations of forest insects appeared to have had little effect in reducing weevil infestations. Birds may be beneficial to the weevil in that the heaviest bird predation occurred during the winter on parasite and predator broods.

PANEL IV - SPECIAL STUDIES

March 16, 8:30 - 12:00 noon

Panel Moderator: B. H. Wilford
Specialists: P. H. Baldwin, J. F. Chansler, D. L. Dahlsten, C. J. DeMars, F. H. Schmidt, M. J. Stelzer, and C. G. Thompson

PROBLEMS IN THE STUDY OF BIRD AND BARK BEETLE RELATIONSHIPS

By

Paul H. Baldwin
Colorado State University
Fort Collins, Colorado

Many problems await study in the area of bird and bark beetle relationships. Among birds involved, woodpeckers are of first importance and have been studied at several bark beetle outbreaks. The role of other types of birds as predators of bark beetles still awaits evaluation. The numerical responses of woodpeckers are not well understood, as it is not known how regularly, how rapidly, or by what means the woodpeckers build up in numbers at infestations. Census methods for woodpeckers have been tested, and the habits of woodpeckers overwintering at bark beetle infestations have been studied. Results reveal the need for individual specific information for each of the different species of woodpecker that feeds on the bark beetles. The role of small secondary bark beetles as a buffer food may attain significance in holding concentrations of woodpeckers. Characteristics of size and accessibility that make bark beetles attractive to woodpeckers should be determined. The effects of birds on the bark beetles has received detailed study only in *Dendroctonus engelmanni* (Hopk.) under epidemic conditions. Study under endemic conditions is needed. Effects of predation on different stages of life history must be evaluated separately. The vulnerability of *D. ponderosae* Hopk. in the flight stage is receiving study currently, and results show that the bark beetles at this time are preyed upon by many species of birds. The problem of degree of regulation exerted by birds and bark beetles upon each other remains relatively unexplored.

COLD RESISTANCE OF *IPS LECONTEI* SW. AND *IPS CONFUSUS*

By

J. F. Chansler
U. S. Forest Service
Rocky Mountain Forest & Range Expt. Station
Albuquerque, New Mexico

Studies on cold-hardening and cold-tolerance of two 5-spined engraver beetles were initiated at the Albuquerque Insect Laboratory in November of 1960. Once each month from November to March, *Ips lecontei* Sw., a pest of

second-growth ponderosa pine was collected from naturally infested trees in central Arizona. During the same week, Ips confusus (Lec.), a pest of pinyon pine was collected from naturally infested trees in northern Arizona. Lots of 50 beetles in petri dishes were cooled to the critical range to calculate changes in cold-hardiness over the winter months. Six-inch bolts were cooled to the critical range to determine the insect's cold-tolerance under the bark. From the experiments it was concluded that: (1) Ips confusus can withstand 5 to 10 degrees colder temperatures than I. lecontei; (2) the cold-hardiness of neither species changed during the months of November through March; (3) when bolts of less than 11 inches in diameter were exposed for 3 hours, 50 percent or greater mortality of I. lecontei began at 0^{o}F. and increased to 100 percent as the temperature dropped to -10^{o}F; with the same size bolts and using the same exposure period, I. confusus mortality approximated 50 percent at -10^{o}F. and increased to 100 percent as the temperature dropped to -20^{o}F.; and (4) length of exposure and bark thickness greatly influence survival.

PREDICTING SEED YIELD REDUCTION IN DOUGLAS-FIR

By

C. J. DeMars
U. S. Forest Service
Pacific Southwest Forest & Range Expt. Station
Berkeley, California

Nine cone bearing Douglas-fir plot trees were established in northwestern California in the summer of 1960. Thirty cones were collected from each tree in mid-July and divided into two lots of 15 cones each. One lot of cones was examined along an axial slice and the other by complete dissection. The seeds were counted and evaluated as to condition: good, hollow, aborted or destroyed by insects (Barbara colfaxiana, Dioryctria abietella, Megastigmus spermotrophus and Contarinia oregonensis). In late August and early September, 30 cones were again collected from each tree, and treated as before. Results showed that predictions based on estimates of the proportion of the seed yield reduction from particular causes were not substantiated. However, when insect-destroyed seed was grouped with hollow and aborted seed as a class called "not-good-seed," there was no significant difference between the two methods tested. There were small, but significant, differences in 4 out of 9 cases between the estimates of percent "not-good-seed" made in mid-July (predictions) and those made in August-September (Harvest). The 5 percent level of significance was used in analysis by Chi-square.

BIONOMICS OF A PINE SAWFLY, NEODIPRION FULVICEPS COMPLEX IN A BRUSHFIELD PLANTATION

By

Donald L. Dahlsten
University of California
Berkeley, California

Investigations of a pine sawfly were initiated in the Mt. Shasta brushfields in 1960. Ponderosa pine has been planted yearly for the past 20 years in areas cleared of brush. The brush is cleared and put into windrows but grows back into these cleared areas rapidly.

This brushfield planting offers a unique area for study; variation in elevation, tree size, and density of brush cover were three of the factors considered in this study. Biological information, mortality data, and attempts to discover why larval eclosion was later at the lower elevation were the main objectives.

One study area was chosen at each of the following elevations: 4,000, 4,500, and 5,000 feet. Ten trees were chosen in each of these areas. A standard weather shelter containing a hygrothermograph was placed in each of the areas also. The total number of eggs was counted and their distribution on the tree plotted. Observations were made about twice a week until the larvae dropped from the tree. A month after cocoon formation, a 4-foot radius of litter was sifted around each of the study trees. In this manner, the biology and the mortality was followed through 1961.

The life history is typical for a Neodriprion sawfly. It is a univoltine insect; eggs are laid on the current year's foliage and they overwinter in this stage. Larval eclosion occurs from April to mid-June. The larvae drop to the ground after 4 to 6 feeding instars and spin cocoons in June and July. The prepupae aestivate, then pupate approximately 3 weeks prior to adult emergence which occurs from mid-October through the first week in November. The cycle is thus completed.

The specimens from Mt. Shasta have been identified as being in the Neodiprion fulviceps complex. There were several differences between two populations in the brushfield: (a) the larvae at the lower elevation emerged 6 weeks later than those at the higher elevations; (b) the larvae had an additional feeding instar at the lower elevation and appeared darker in their coloration; (c) the female adults were larger at the lower elevation; and (d) the females in the lower area lay purple eggs while those in the upper areas lay green eggs. This evidence indicates that there may be two species present in the brushfield.

A preliminary analysis of the mortality data indicates a higher egg mortality at 5,000 feet due to cold weather and parasites, a higher incipient larva mortality at the 4,500-foot level due to cold weather, and a higher feeding larva mortality at the 4,000-foot level due to an influx of Evening Grosbeaks. The total mortality in each of the areas was approximately 65 percent. The analysis of all the mortality data will be completed in the near future and a partial life table will be constructed for the 1961 generation.

INSECT PHYSIOLOGY IN FOREST ENTOMOLOGY

By

Fred H. Schmidt
Pacific Northwest Forest & Range Expt. Station
Forest Entomology Laboratory
Corvallis, Oregon

I would like to divide this talk into three major divisions. First, I would like to consider some aspects of the rationale underlying the formulation and the effecting of a research program in insect physiology. Second, I would like to consider, briefly, how such a research program could best be coordinated with those of us working in more applied areas of forest entomology. Finally, I would like to focus your attention on certain areas of research in insect physiology which hold great promise for the future, and which should be given high priority during the programming of future research.

Now then, what factors would influence the selection and scope of a program of research in insect physiology as it relates to forest entomlogy?

The physiology of insects does not appear to differ drastically from insect to insect. By this, I do not mean that most insects, or even closely related species, have exactly the same life history, behavior, diapausing requirements, or other identical physiological responses. Rather, I mean that the mechanisms through which these events take place appear to be very similar. Hence, the majority of female insects must be fertilized before the embryo can develop beyond a given point. The embryological development follows a similar sequence of events. Most insects are oviparious. The metabolic pathways, in almost all insects that have been studied, have been identical.

Insects may be classified into just a few major feeding-groups, and in the case of insects that we would be primarily concerned with, include the leaf-feeders, the wood-feeders (including bark beetles), and some sucking insects. The latter groupings are reasonable and sound because the concentration of the major constituents of the food type, such as the concentration of protein carbohydrate, cellulose, or other food materials, differ but little within each group, but differ markedly between groups. Thus, a qualitative and quantitative analysis of the leaf constituents of two species of trees are far more similar than a similar analysis of the leaves of one species and the wood of the same tree, the same species, or another species.

Similarities such as those mentioned above and others, allow an insect physiologist to make some intelligent guesses as to a given physiological response in a specific forest insect species which may as yet be comparatively little studied. And, although the physiology of forest insects has been little investigated, particularly in the United States, much useful knowledge can still be obtained from physiological studies of non-forest insects, and we have, therefore, much inherited information, if you like, on which we can base our future research.

In point of fact, many of the previous generalizations can be determined and placed in their proper perspective only after the intensive study of the exceptional or anomalous conditions found in certain insect systems or in mutant strains of the normal systems. Thus, much information can be obtained concerning normal ovigenesis in insects by studying mutant strains which require special conditions, whether they be nutritional or ecological in nature or whether they require specialized behavioral adaptations, before the ovary of the female will be allowed to develop.

Other physiological processes can also be better understood by a study of abnormal conditions. The nutrition of larval growth and development can often be elucidated through the study of mutants with special requirements. Metabolic pathways are often difficult to study without mutant forms which have specific requirements. Diapause in insects can best be studied by selecting two populations of a given species, one population of which undergoes diapause and the other of which does not. Melanism, or color variation, can usually be most rewardingly studied by comparing insects of normal coloration with those of abnormal coloration within the same species. It can soon be seen that results are usually more rapid and significant when comparative studies are undertaken. And the significance of these results and their usefulness can be enhanced if the results apply to two or more species of insects. Needless to say, there are a substantial number of areas other than those already mentioned that are in need of investigation and, perhaps, with more urgency. The above were used merely for illustrative purposes.

Lest the above be misinterpreted and considered a gross over-simplification, it should quickly be stated that in spite of these generalizations they still do not fully explain certain events which seemingly have a physiological basis, and there are still many exceptions, some of which directly involve forest insect pests. Indeed, if there were no exceptions, there would be no need for an insect physiologist to work specifically on the physiology of forest insects, and we would rely on other insect physiologists to gather the information that we could use in our own work. Most of us, however, recognize the uniqueness of some of our insect problems, and these unquestionably justify a research program in the physiology of forest insects.

Now, what would be the goals in studying the physiology of insects as it is related to forest entomology? They are the same as they are in other studies of insect physiology that are related to applied fields such as forest entomology - namely, to attempt to better understand the vital functions of insects, and to attempt to identify and characterize vulnerable steps in their development, behavior, or life processes which might subsequently be used to increase the efficiency of insect-control programs.

How can an insect physiology program in forest entomology be best effected, and the above objectives realized? With my limited experience in forest entomology and in the West, I would greatly appreciate talking with many of you, and learning of as many of your problems as possible. Many of these problems will not adapt themselves very well to a laboratory study or fit into our over-all program, but others undoubtedly will and we shall make every effort to consider them. Also, by talking with you, I hope

that I can learn of your interests and programs, with the expectation that we could give one another complementary assistance.

Finally, what areas of research in insect physiology should, in my opinion, be stressed?

One of the most important areas that warrants immediate and intensive attention is that of the physiology of reproduction. In observing the rise and fall of insect pest populations in the field, few workers question that many interacting, dynamic forces influence population flux. Perhaps the most important and fundamental process concerned with population dynamics is that of the reproduction of a particular pest, as well as the reproduction of the prime controlling organisms. Answers to certain basic questions may enable us to favorably influence the reproductive capacity of these controlling organisms and/or to unfavorably influence the reproductive capacity of the pest. Yet, comparatively little is known regarding the physiology of reproduction, and there are comparatively few insect physiologists that are actively working in this area.

Another area which warrants further attention is that of sensory physiology, and, in particular, the study of attractants and repellents and their mode of action. Included are those that elicit sexual or aggregation behavior, orientation to food, and a response to the food once feeding has been initiated. Relatively few of these substances have been isolated, characterized, and synthesized in spite of the concentrated effort to do so in recent years. The acquisition of such substances would give the forest entomologist a valuable tool with which he could manipulate an insect pest so as to minimize its damage. Speaking allegorically, an economic entomologist with such a tool would have the power of a modern Pied Piper.

Insect endocrinology is an area of research whose surface has hardly been scratched, despite the extensive literature on the subject. From the evidence available, insects appear to be far more reliant on hormonal control of their vital systems than higher animals. Yet, only two insect hormones, ecdysone and neotenin, have been isolated and purified, but only ecdysone has been partially characterized and neither have been synthesized to date. There is, however, much evidence for other hormones, including the brain or prothoracotropic hormone, probable metabolic hormones, a possible gonadotropic hormone(s), and a hormone referred to as the "diapause factor." Since hormones play such an influential role in insect growth, development, metabolism, and other vital functions, it seems not only proper but essential to stress the importance of research in insect endocrinology. In addition, the study of endocrinology may have immediate application to the economic entomologist seeking an effective control for a pest, for C. M. Williams of Harvard University, has expressed the opinion (Sci. Amer. 198:74) that ".... we may be able to use insect hormones as an insecticide - a truly perfect insecticide, for the insects could hardly evolve a resistance to their own hormones."

The need for additional knowledge in nutrition for our specific forest insect pests is probably quite apparent. If the nutritional needs for an insect pest were known, forests could be genetically modified to make them

inadequate food sources; thus decreasing the successfulness and economic importance of the pest. Along the same line of thinking, there is also evidence to support the fact that the enrichment or deficiency of a diet with certain nutrients will result in certain mutations in the insects that have fed on the diet.

Other areas, such as insect behavior, diapause, and metabolism, hold many challenges in physiological research, not to mention the many challenges in biochemical research, such as the function of many vitamins in the metabolic pathways of insects, the pathways and direction of various metabolic pathways, and the synthesis of vitamins, enzymes, and nutrients which are known to be required by other animals, but are, apparently, synthesized by insects. The undertaking of any of these challenges and their elucidation will not only benefit the insect physiologist, hence the applied forest entomologist, but will also benefit other workers in animal and plant physiology and biochemistry, whose previous findings have allowed the entomologist to progress as rapidly as he has and to view his accomplishments with some perspective.

BIOLOGY AND NATURAL CONTROL OF *MALACOSOMA FRAGILE*, THE GREAT BASIN TENT CATERPILLAR

By

M. J. Stelzer
U. S. Forest Service
Rocky Mountain Forest & Range Expt. Station
Albuquerque, New Mexico

Epidemics of the Great Basin tent caterpillar, *Malacosoma fragile* (Stretch) have occurred at periodic intervals for many years in the trembling aspen stands of northern New Mexico and southern Colorado.

Defoliation causes a marked reduction in radial increment. Also, the widespread occurrence of dead and dying trees is probably related to the repeated defoliations by this pest.

The life history of this insect in New Mexico was studied during 1961. The larvae hatch during the latter part of May after overwintering as first instar larvae within the egg. The larvae pass through 5 instars during a feeding period of approximately 5 weeks.

Natural mortality factors were also investigated. Egg parasites were found to account for about 5 percent mortality. Pupal mortality by hymenopterous and dipterous parasites amounted to 23 percent in 1961. Approximately 20 percent of the tent caterpillar colonies contained larvae killed by a naturally occurring polyhedrosis virus. However, no appreciable effect on the over-all population trend could be detected.

The incidence of virus mortality was increased to 90 percent after artificial dissemination of virus in infested areas.

VIRUS DISEASES OF INSECTS

By

C. G. Thompson
U. S. Forest Service
Pacific Northwest Forest & Range Expt. Station
Forest Entomology Laboratory
Corvallis, Oregon

Wilt diseases of lepidopterous larvae have been recognized for more than 50 years. The presence of polyhedial inclusions in the bodies of diseased insects was noted early in the study of these diseases. Some time elapsed before the viral nature of these diseases was established and it was not until after World War II that Bergold actually isolated and photographed with the electron microscope, the rod-shaped virus particle. With the greatly increased attention given to the insect virus diseases in the post war years, our knowledge of them has expanded considerably. Insect viruses have now been categorized into a number of taxonomic groups although we have, as yet, been unable to establish a workable taxonomy below the generic level. Several species of pest insects have been successfully controlled experimentally by artifical application of virus material. By 1950 it appeared to many of us that the only unsolved problem remaining before polyhedrosis viruses could be routinely used as "biological insecticides" was that of mass producing the viruses in sufficent quantity.

Mass production of many of the viruses is still an unsolved problem but it is now just one of many problems. The epizootiology of polyhedroses is not nearly as simple as we once thought. We cannot now treat all polyhedroses as having a single, simple epizootiology. In fact, it now appears necessary to treat each virus disease separately and to expect it to differ in a greater or lesser degree from all other insect viruses, even those in the same "generic" group. Where the same virus is found virulent to several species of host insects (as in the genus Malacosoma, the tent caterpillar) we may find the epizootiology differs with the host species.

Virus virulence (or host susceptibility) varies considerably, even among the nuclear polyhedroses of Lepidoptera. The LD-50 may vary from less than 100 to more than 100,000 polyhedra per insect, depending on the virus, the host species, and the age of the host insect. The age at which the insect is susceptible to lethal infection varies greatly from species to species. With some species (for example the forest tent caterpillar, Malacosoma distria) it appears almost impossible to achieve infection under field conditions. These latter cases are baffling in that nature often achieves what man is unable to do. Natural epizootics of polyhedrosis may result in the almost complete collapse of forest tent caterpillar populations.

Natural epizootics often give the appearance of showing up suddenly in massive proportions without the progressive build-up we would expect of a contagious disease. In most cases we have little knowledge of the disease incidence in the generations proceeding the epizootic and it is quite possible for disease occurring at a low incidence to escape detection. In many cases, however, there is considerable evidence that something other

than contagion is responsible for the sudden appearance of an epizootic. Latent virus infections are now believed to play a significant role in some epizootics. Our knowledge of generation to generation transmission of virus diseases is scanty, but there is some evidence that this may mask the true period of contagion and disease transmission between individual hosts.

It is evident from the problems described above that much remains to be learned of the nature of virus diseases and the epizootics they produce. Before we can intelligently use some of the insect viruses in biological control we will have to know more about them. In the meantime, however, we should not overlook the immediate possibilities of applied use of some of the more virulent viruses. The Douglas-fir tussock moth gives considerable promise of lending itself to applied control measures using a polyhedrosis virus, and the Great Basin tent caterpillar, likewise, should not be overlooked. Very rewarding results have come from virus treatments of several species of sawflies.

MINUTES OF FINAL BUSINESS MEETING

March 16, 1962

Chairman Bill Wilford called the meeting to order at 1:00 p.m. in the Varsity Room of the Pioneer Hotel.

The Secretary-Treasurer read the minutes of the Initial Business Meeting. After minor corrections Ken Wright moved that they be approved. Motion seconded by George Struble. Carried.

The Chairman asked the Nominating Committee for their recommendations for candidates for Chairman, Secretary-Treasurer, and Councilor. Tom Silver, Chairman of the Nominating Committee recommended the following: Ken Wright to serve as Chairman; Peter Orr, Secretary-Treasurer and Roy Shepherd, Councilor.

Chairman Bill Wilford asked for nominations from the floor.

Bob Stevens moved that nominations be closed. Motion seconded by Tom Harris. Carried. The new officers were approved by acclamation.

The Chairman called for Ken Wright, Chairman Pro tem of the Ethical Practices Committee to come forward and report on his Committee's work in selecting a new Chairman.

Before Ken Wright could reach the platform, Ron Stark asked for and was granted audience to present a resolution. The resolution is as follows:

> In a rump session of a number of our colleagues the following resolution was proposed:
>
> WHEREAS the acting Chairman, pro tem of the Ethical Practices Committee has committed one of the gravest errors in judgment and behavior as set forth by the American sociologist, Mr. Robert Newhart, an expert on mores and behavior for convention delegates; to wit bringing his wife and
>
> WHEREAS, although this breach of etiquette is tolerable in lesser men, it is patently impossible for the Chairman of this important Committee to discharge his duties properly under these circumstances:
>
> BE it resolved that Mr. Kenneth Wright be suitably chastized and prevented from ever holding this important post again.

The resolution was seconded by Tom Silver. Resolution carried (58 in favor, 5 opposed).

After a lively discussion, Ken Wright gave an excellent review of the Ethical Practices Committee's history and the findings of his Committee. Ken then asked Tom Silver to come forward and accept the "badges of office" for being selected as the new Chairman of the Ethical Practices Committee.

Returning to a more serious light, Norm Johnson moved that the Fourteenth Annual meeting be held in the Portland area, preferably the last week of February or the first week of March 1963. George Struble seconded the motion. Motion carried.

The Chairman asked the group to select a program theme. The two topics presented by the Executive Committee were restated and are as follows:

1. Research, development, and methodology. To include an appraisal of where we are going in forest entomology research and some of the methods used to get there.

2. Research Seminar, to consist of formal papers such as were given during the last part of this year's work conference, but with additional time given for discussion.

A third proposal was made by Norman Johnson as follows:

3. "Where are we going in Forest Entomology Research?" Topic to consist of a number of work shops to discuss guidelines for future research in the expanding fields in forest entomology. Included in the work shops will be educators, forest entomologists, foresters, entomology specialists and newcomers to entomology.

Norman Johnson's motion that we adopt the third proposal was seconded by Bob Furniss. Bob also commented that selection of this theme would enable the conference to return to its original concept.

Stark, Beal, Trostel and Wygant all endorsed the selection to proposal number three as the theme. Motion carried by unamious approval. The theme for the Fourteenth Annual Work Conference will be "Where are we going in Forest Entomology Research?"

Norman Johnson was selected as Program Chairman for the 1963 meeting.

Report of the Standing Committees:

A. Common Names Committee: Chairman Phil Johnson proposed that appointments to the Common Names Committee be restricted to a 5-year term. The appointments be staggered; the conference Chairman appoint one new member to the Committee on every even year and two new members on every odd year. Bob Stevenson moved the proposal be adopted; seconded by George Struble. Motion carried.

B. Education Committee: Chairman Ron Stark reported that Dr. Floyd Werner had been appointed to the Education Committee. No formal report was presented.

The problem of how to handle the insect conditions report was brought up again. Some members want to discontinue presenting this subject. Other members want to see it continued.

Galen Trostle moved that the conference Chairman appoint a member to prepare a summarized report of insect conditions. This summary report then be

reproduced and made available to the membership at the meeting, thus eliminating a verbal presentation. Paul Buffam seconded the motion. Motion carried.

Bob Furniss felt that there were too many items of business presented at the final business meeting. Bob suggested to the new Chairman that the main portion of the business meeting be held during the initial business meeting.

Amel Landgraf felt that the duties of the Secretary-Treasurer had increased to a point where they require too much time for one person to handle. Several attending members also felt that there should be a Secretary and a Treasurer. Amel offered to revise the constitution to include this change.

Bill Wilford turned the meeting over to Ken Wright, the new Conference Chairman. Ken asked the group to show their appreciation by applause to Cal Massey for the outstanding program and local arrangements for the Thirteenth Annual Meeting.

Meeting adjourned at 2:30 p.m.

APPENDIX

REPORT OF THE COMMITTEE ON COMMON NAMES OF WESTERN FOREST INSECTS WESTERN FOREST INSECT WORK CONFERENCE, TUCSON, ARIZONA

March 13-16, 1962

The Committee in July adopted a new form (copy attached) for proposing common names of western forest insects. Copies of the form are available at the following locations:

1. Canadian forest biology laboratories:

   Victoria, British Columbia
   Vernon, British Columbia
   Calgary, Alberta

2. U. S. Forest Service, Forest and Range Experiment Stations:

   Portland, Oregon
   Berkeley, California
   Missoula, Montana
   Ogden, Utah
   Fort Collins, Colorado
   Albuquerque, New Mexico

3. Educational institution entomology departments:

   University of British Columbia, Vancouver
   Washington State University, Pullman
   Oregon State University, Corvallis
   University of California, Berkeley
   University of Idaho, Moscow
   Montana State College, Bozeman
   Utah State University, Logan
   Colorado State University, Fort Collins

The following common names were approved by the Committee and are currently awaiting approval or rejection by Conference members:

Barbara colfaxiana (Kearfott)	Douglas-fir cone moth
Ergates spiculatus Leconte	Ponderous borer
Ips lecontei Swaine	Arizona five-spined ips
Kalotermes minor (Hagen)	Western drywood termite
Melanophila gentilis Leconte	Flatheaded pine borer
Platypus wilsoni Swaine	Western platypus
Zelleria haimbachi Busck	Pine needle-sheath miner
Zootermopsis angusticollis (Hagen)	Coastal dampwood termite
Pseudohylesinus grandis Swaine	Silver fir beetle
Pseudohylesinus granulatus (Leconte)	Fir root beetle

The Committee rejected the following proposed common names either because they were felt to be inadequately descriptive, or because of impending taxonomic changes that could render approved common names inappropriate:

Hadrobregmus gibbicolis (Leconte)	California deathwatch beetle
Contarinia oregonensis Foote	Douglas-fir seed midge
Ips emarginatus (Leconte)	Emarginate ips
Ips oregonis (Eichhoff)	Oregon ips
Ips radiatae Hopkins	Monterey pine ips

Respectfully submitted,

COMMON NAMES COMMITTEE

Clifford E. Brown, Calgary
Valentine M. Carolin, Portland
Robert E. Denton, Missoula
David Evans, Victoria
Norman E. Johnson, Centralia
Philip C. Johnson, Missoula (Chm.)
George R. Struble, Berkeley

Tucson, Arizona
March 13, 1962

Western Forest Insect Work Conference

PROPOSAL FOR COMMON NAME

The Conference Committee On Common Names Of Western Forest Insects is asked to consider the adoption of the common name hereinafter proposed (see "NOTE")

PART A. (To be completed by proposer) Date ____________

1. Scientific name of insect ____________
2. Order ____________ 3. Family ____________
4. Proposed common name ____________
5. Proposer's name (Dr., Mr., Mrs., Miss) ____________
6. Proposer's address ____________
7. Reasons for proposing common name:

   a. Economic importance _____
   b. Striking appearance _____
   c. Abundance _____
   d. Already in general usage _____
   e. Other (explain) _____

8. Stage(s) to which proposed common name applies:

9. Characteristic appearance of stage to be named, if proposed common name is to be based on this appearance:

10. Habits of stage to be named if proposed common name is to be based on these habits:

11. Other reasons supporting the need for a common name for this insect:

NOTE: The proposer is urged to familiarize himself with the following references before submitting this form:

METCALF, C. L. 1942. Common names of insects. Jour. Econ. Ent. 35(5): 795-797. (editorial).

ANONYMOUS. 1953. An appeal for a clearer understanding of principles concerning the use of common names. Appendix to the proceedings of the 64th annual meeting of the American Association of Economic Entomologists, Philadelphia, Penn., December 15-18, 1952. Jour. Econ. Ent. 46(1): 207-211.

LAFOON, JEAN L. 1960. Common names of insects approved by the Entomological Society of America. Bul. Ent. Soc. Amer. 6(4): 175-211.

FURTHER INSTRUCTIONS: Complete this form in duplicate. Send to Conference Secretary or to Common Names Committee Chairman.

12. States, Provinces, or Territories where insect has been reported:

13. Principal host plants of insect:

14. Economic importance of the insect for which the common name is proposed:

15a. References containing previous uses of proposed common name:

15b. References using other common names than that proposed here (give names):

16. Other insects to which the proposed common name might apply:

PART B. (To be used by the Common Names Committee, WFIWC)

Committee members will indicate by "X" their approval or rejection of the proposed common name presented above. If proposal is rejected, attach reasons on a separate sheet.

Committee Members	Member Signatures	Approved	Rejected

Final Action	Approved	Rejected	Date
WFIWC, Committee On Common Names			
WFIWC, Membership At Large			
ESA, Committee On Common Names			

____________________ Date ____________
Committee Chairman

STATUS OF INDEXES TO UNPUBLISHED REPORTS UP TO 1960

Center	Coverage by index	Coverage by supplements
Alaska	Up to 1957	1958 - 1960
Alberquerque	1951 - 1958	1955 - 1960
Berkeley	None	None
Calgary	Up to 1957	1958 - 1960
Ft. Collins	1935 - 1953	1954 - 1960
Missoula	1915 - 1959	None
Ogden	None	None
Portland	None	1959 - 1961
Vernon	1926 - 1956	None
Victoria	1927 - 1957	None

Submitted by,

Roy F. Shepherd, Chairman
Committee on Indexing of
Reports and Publications

COMMITTEE MEMBERSHIP

Common Names Committee

P. C. Johnson, Chairman

C. E. Brown

V. M. Carolin

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N. E. Johnson

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Education Committee

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Note: Active members registered at the Conference in Tucson, Arizona, March 13-16, 1962, are indicated by an asterisk (*).

USFS REGION 1 (Missoula) and REGION 4 (Ogden)

CAHILL, DONALD B.
(Entomologist)
Division of Timber Management
U. S. Forest Service
Forest Service Building
Ogden, Utah

COLE, WALTER E.
(Entomologist)
Division of Forest Insect Research
Intermountain Forest and Range Experiment Station
Forest Service Building
Ogden, Utah

COX, ROYCE E.
(Forester)
Potlatch Forests, Inc.
Lewiston, Idaho

DAVIS, Dr. DONALD A.
(Associate Professor)
Dept. of Zoology and Entomology
Utah State University
Logan, Utah

DENTON, ROBERT E.
(Entomologist)
Intermountain Forest and Range Experiment Station
Federal Building
Missoula, Montana

FELLIN, DAVID G.
(Entomologist)
Intermountain Forest and Range Experiment Station
Federal Building
Missoula, Montana

*FURNISS, MALCOM M.
(Entomologist)
Intermountain Forest and Range Experiment Station
316 East Myrtle Street
Boise, Idaho

*GROSSENBACH, PAUL A.
(Forester)
Division of Timber Management
U. S. Forest Service
Forest Service Building
Ogden, Utah

HARTMAN, HOMER J.
(Forester)
Div. of State & Private Forestry
U. S. Forest Service
Federal Building
Missoula, Montana

*JOHNSON, PHILIP C.
(Entomologist)
Intermountain Forest and Range Experiment Station
Federal Building
Missoula, Montana

KNOPF, JERRY A. E.
(Entomologist)
Division of Timber Management
U. S. Forest Service
Forest Service Building
Ogden, Utah

KNOWLTON, Dr. GEORGE F.
(Professor of Entomology)
Utah State University
Logan, Utah

REGIONS 1 and 4 Continued

MANIS, Dr. H. C.
(Head)
Dept. of Entomology
University of Idaho
Moscow, Idaho

McGREGOR, M. D.
(Entomologist)
Division of Timber Management
U. S. Forest Service
Forest Service Building
Ogden, Utah

*PARKER, D. E.
(Chief)
Division of Forest Insect Research
Intermountain Forest and Range
Experiment Station
Forest Service Building
Ogden, Utah

SCHENK, Dr. JOHN A.
(Associate Professor)
University of Idaho)
Moscow, Idaho

SCHMITZ, RICHARD F.
(Entomologist)
Intermountain Forest and Range
Experiment Station
Federal Building
Missoula, Montana

*SCOTT, DAVID O.
(Forester)
Div. of State & Private Forestry
U. S. Forest Service
Federal Building
Missoula, Montana

*TERRELL, TOM T.
(Entomologist)
Div. of State & Private Forestry
U. S. Forest Service
Federal Building
Missoula, Montana

*TROSTLE, GALEN C.
(Entomologist)
Division of Timber Management
U. S. Forest Service
Forest Service Building
Ogden, Utah

TUNNOCK, SCOTT
(Entomologist)
Div. of State & Private Forestry
U. S. Forest Service
Federal Building
Missoula, Montana

*WASHBURN, RICHARD I.
(Entomologist)
Division of Timber Management
U. S. Forest Service
Forest Service Building
Ogden, Utah

USFS REGION 2 (Denver)
and REGION 3 (Albuquerque)

BAILEY, WILMER F.
(Forester)
Division of Timber Management
U. S. Forest Service
Denver Federal Center, Bldg. 85
Denver 25, Colorado

*BALDWIN, Dr. PAUL
(Zoologist)
Department of Zoology
Colorado State University
Fort Collins, Colorado

*BARDEN, PAT
(Forester)
Bureau of Land Management
910 15th Street
Denver, Colorado

BERRY, Dr. DICK W.
(Assistant Professor)
Division of Forestry
Arizona State College
Flagstaff, Arizona

BORDEN, TOM B.
(State Forester)
Colorado State Forest Service
Colorado State University
Fort Collins, Colorado

*CHANSLER, JOHN F.
(Entomologist)
Rocky Mountain Forest and Range
Experiment Station
P. O. Box 523
Albuquerque, New Mexico

DURKIN, J. J.
Dept. of Entomology
New Mexico A & M College
State College, New Mexico

ELLIOTT, GAIL
(Forester)
Bureau of Land Management
2002 Capitol Avenue
Cheyenne, Wyoming

*HESTER, D. A.
(Forester)
Division of Timber Management
U. S. Forest Service
Denver Federal Center, Bldg. 85
Denver, Colorado

*JAMES, WILLIAM
(Regional Chief)
National Park Service
Branch of Park Forest and
Wildlife Protection
Box 1728
Santa Fe, New Mexico

*LANDGRAF, AMEL E., Jr.
(Forester)
Division of Timber Management
U. S. Forest Service
Denver Federal Center, Bldg. 85
Denver 25, Colorado

LINDSTEN, A.
(Forester)
Southwestern Forest Industries
McNary, Arizona

*McCAMBRIDGE, W. F.
(Entomologist)
Rocky Mountain Forest and
Range Experiment Station
Colorado State University
221 Forestry Bldg.
Fort Collins, Colorado

McKNIGHT, MELVIN E.
(Entomologist)
Rocky Mountain Forest and Range
Experiment Station
Colorado State University
221 Forestry Bldg.
Fort Collins, Colorado

*MASSEY, Dr. CALVIN L.
(Entomologist)
Rocky Mountain Forest and
Range Experiment Station
P. O. Box 523
Albuquerque, New Mexico

MESO, STANELY W., Jr.
(Forester)
Division of Timber Management
U. S. Forest Service
Denver Federal Center, Bldg. 85
Denver 25, Colorado

MOGREN, Dr. E. W.
(Associate Professor)
College of Forestry and
Range Management
Colorado State University
Fort Collins, Colorado

NAGEL, ROY H.
(Entomologist)
Rocky Mountain Forest and Range
Experiment Station
Colorado State University
221 Forestry Building
Fort Collins, Colorado

*PIERCE, D. A.
(Entomologist)
Division of Timber Management
U. S. Forest Service
Federal Building
517 Gold Ave., S. W.
Albuquerque, New Mexico

*PILLMORE, RICHARD E.
(Res. Biologist-Pesticide Project)
Bureau of Sport Fisheries & Wildlife
Denver Research Center
Denver Federal Center, Bldg. 22
Denver 25, Colorado

*STELZER, MILTON J.
(Entomologist)
Rocky Mountain Forest and Range
Experiment Station
P. O. Box 523
Albuquerque, New Mexico

THATCHER, Dr. T. O.
(Professor)
Dept. of Entomology
Colorado State University
Fort Collins, Colorado

*WERNER, Dr. F. C.
Dept. of Entomology
University of Arizona
Tucson, Arizona

*WILFORD, Dr. B. H.
(Entomologist)
Rocky Mountain Forest and Range
Experiment Station
South Hall, C.S.U.
Fort Collins, Colorado

*WYGANT, Dr. NOEL D.
(Chief)
Division of Forest Insect Research
Rocky Mountain Forest and Range
Experiment Station
Colorado State University
221 Forestry Building
Fort Collins, Colorado

*YASINSKI, F. M.
(Entomologist)
Division of Timber Management
U. S. Forest Service
Federal Building
517 Gold Ave., SW
Albuquerque, New Mexico

USFS REGION 5 (Berkeley)

AVERELL, J. L.
(Forester)
U. S. Forest Service
630 Sansome Street
San Francisco 11, California

BEDARD, W. D.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

*BUSHING, R. W.
(Laboratory Technician)
Dept. of Entomology & Parasitology
Agriculture Hall
University of California
Berkeley 4, California

*DAHLSTEN, Dr. D. L.
(Assistant Professor)
Dept. of Zoology
Los Angeles State College
Los Angeles 32, California

*DeMARS, C. J.
(Entomologist)
Div. of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

*DOTTA, DANIEL D.
(Forest Technician)
California Div. of Forestry
State Office Bldg. No. 1
Room 354
Sacramento 14, California

*DOWNING, GEORGE L.
(Entomologist)
U. S. Forest Service
630 Sansome Street
San Francisco 11, California

EATON, CHARLES B.
(Chief)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

FLESCHNER, Dr. C. A.
Dept. of Biological Control
University of California
Riverside, California

HALL, Dr. RALPH C.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

*HARRIS, T. H.
(Forester)
U. S. Forest Service
630 Sansome Street
San Francisco 11, California

*JESSEN, ERIC
(Entomologist)
U. S. Forest Service
630 Sansome Street
San Francisco 11, California

KEEN, F. P.
1054 Oak Hill Road
Lafayette, California

*KOERBER, T. W.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

LYON, Dr. R. L.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

REGION 5 Continued

MAHONEY, JOHN
(Chief Forester)
National Park Service, R-4
180 New Montgomery Street
San Francisco, California

MARSHALL, KNOX
Western Pine Association
1100 Tenth Avenue
Sacramento 18, California

ORR, JOSEPH L.
(Forester)
National Park Service
Yosemite National Park, Calif.

PIERCE, J. R.
(Entomologist)
c/o San Bernardino National Forest
P. O. Box 112
San Bernardino, California

SMITH, RICHARD H.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

*STARK, Dr. R. W.
(Associate Professor)
Dept. of Entomology & Parasitology
University of California
Berkeley 4, California

*STEVENS, ROBERT E.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

*STRUBLE, G. R.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

STURGEON, Dr. E. E.
Division of Natural Resources
Humboldt State College
Arcata, California

SWAIN, K. M.
(Entomologist)
U. S. Forest Service
630 Sansome Street
San Francisco 11, California

*VITÉ, Dr. JEAN PIERRE
B.T.I. For. Research Laboratory
P. O. Box 1119
Grass Valley, California

WICKMAN, BOYD E.
(Entomologist)
Division of Forest Insect Research
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley 1, California

*WOOD, Dr. D. L.
(Assistant Entomologist)
Dept. of Entomology & Parasitology
University of California
Berkeley 4, California

USFS REGION 6 (Portland)

ALLEN, Dr. GEORGE A.
(Director)
Weyerhaeuser Research Center
P. O. Box 420
Centralia, Washington

BROCKMAN, Prof. C. FRANK
(Professor of Forestry)
College of Forestry
University of Washington
Seattle, Washington

BRAIDWOOD, JOHN C.
(Forester)
Division of Timber Management
U. S. Forest Service
P. O. Box 3623
Portland 8, Oregon

*BUFFAM, P. E.
(Entomologist)
Division of Timber Management
U. S. Forest Service
P. O. Box 3623
Portland 8, Oregon

CAROLIN, V. J., Jr.
(Entomologist)
Division of Forest Insect Research
Pacific Northwest Forest and
Range Experiment Station
P. O. Box 3141
Portland 8, Oregon

CHAMBERLIN, Dr. W. J.
3320 Chintimini Avenue
Corvallis, Oregon

CORNELIUS, ROYCE O.
(Managing Forester)
Weyerhaeuser Company
Tacoma Building
Tacoma 1, Washington

*COULTER, WILLIAM K.
(Entomologist)
Division of Forest Insect Research
Pacific Northwest Forest and
Range Experiment Station
P. O. Box 3141
Portland 8, Oregon

FINK, CLIFFORD R.
(Forester)
Division of Timber Management
U. S. Forest Service
P. O. Box 3623
Portland 8, Oregon

*FURNISS, R. L.
(Chief)
Division of Forest Insect Research
Pacific Northwest Forest and
Range Experiment Station
P. O. Box 3141
Portland 8, Oregon

GUY, W. C.
(Photographer)
Division of Forest Insect Research
Pacific Northwest Forest and
Range Experiment Station
P. O. Box 3141
Portland 8, Oregon

*HOWARD, BENTON
(Forester)
Division of Timber Management
U. S. Forest Service
P. O. Box 3623
Portland 8, Oregon

JAENICKE, A. J.
2941 Mulkey Street
Corvallis, Oregon

*JOHNSON, Dr. N. E.
(Entomologist)
Weyerhaeuser Research Center
P. O. Box 420
Centralia, Washington

LARSEN, A. T.
(Forester-Pilot)
Oregon State Dept. of Forestry
2600 State Street
Salem, Oregon

LAUTERBACH, PAUL G.
(Research Forester)
Weyerhaeuser Research Center
P. O. Box 420
Centralia, Washington

MITCHELL, Dr. RUSSEL G.
(Entomologist)
Division of Forest Insect Research
Pacific Northwest Forest and
Range Experiment Station
P. O. Box 3141
Portland 8, Oregon

*ORR, P. W.
(Entomologist)
Division of Timber Management
U. S. Forest Service
P. O. Box 3623
Portland 8, Oregon

PEARSON, ERNEST D.
(Forester)
Oregon State Dept. of Forestry
2600 State Street
Salem, Oregon

*RITCHER, Dr. PAUL O.
(Head)
Department of Entomology
Oregon State University
Corvallis, Oregon

RUDINSKY, Dr. JULIUS A.
(Professor)
Entomology Department
Oregon State University
Corvallis, Oregon

RYAN, Dr. ROGER
(Entomologist)
Pacific Northwest Forest and
Range Experiment Station
Forestry Sciences Laboratory
3200 Jefferson Way
Corvallis, Oregon

*SCHMIDT, FRED H.
(Entomologist)
Pacific Northwest Forest and
Range Experiment Station
Forestry Sciences Laboratory
3200 Jefferson Way
Corvallis, Oregon

TELEFORD, Dr. HORACE S.
(Chairman)
Dept. of Entomology
Washington State University
Pullman, Washington

*THOMPSON, Dr. C. G.
(Entomologist)
Pacific Northwest Forest and
Range Experiment Station
Forestry Sciences Laboratory
3200 Jefferson Way
Corvallis, Oregon

WEAR, J. F.
(Research Forester)
Division of Forest Insect Research
Pacific Northwest Forest and
Range Experiment Station
P. O. Box 3141
Portland 8, Oregon

*WRIGHT, KENNETH H.
(Entomologist)
Division of Forest Insect Research
Pacific Northwest Forest and
Range Experiment Station
P. O. Box 3141
Portland 8, Oregon

WITTIG, Dr. GERTRAUDE C.
Pacific Northwest Forest and
Range Experiment Station
Forestry Sciences Laboratory
3200 Jefferson Way
Corvallis, Oregon

USFS REGION 10 (JUNEAU)

*CROSBY, DAVID
(Entomologist)
Division of Timber Management
U. S. Forest Service
Box 1631
Juneau, Alaska

ROSE, W. E.
(Entomologist)
Northern Forest Expt. Station
Box 740
Juneau, Alaska

SCHMIEGE, Dr. DONALD E.
(Entomologist)
Northern Forest Expt. Station
Box 740
Juneau, Alaska

WASHINGTON, D. C.

BAKER, W. L.
(Assistant Director)
Division of Forest Insect Research
U. S. Forest Service
Washington 25, D. C.

*BEAL, Dr. J. A.
(Director)
Division of Forest Insect Research
U. S. Forest Service
Washington 25, D. C.

*BENEDICT, W. V.
(Director)
Division of Forest Pest Control
U. S. Forest Service
Washington 25, D. C.

BONGBERG, J. W.
(Chief)
Branch of Forest Insect Surveys
U. S. Forest Service
Washington 25, D. C.

*CARLSON, S. T.
(Chief)
Branch of Park Forest and
Wildlife Protection
National Park Service
Room 244, Interior Bldg.
Washington 25, D. C.

*RINDT, CHARLES R.
(Forester)
Division of Timber Management
U. S. Forest Service
Washington 25, D. C.

*WHITESIDE, J. M.
(Assistant Director)
Division of Forest Pest Control
U. S. Forest Service
Washington 25, D. C.

CANADA (Calgary)

*BROWN, E. C.
(Associate Forest Biologist)
Forest Entomology & Pathology Lab.
Department of Forestry
102 11 Avenue, East
Calgary, Alberta

COOK, J. A.
(Associate Forest Biologist)
Forest Entomology & Pathology Lab.
Department of Forestry
102 11 Avenue, East
Calgary, Alberta

*HOPPING, GEORGE R.
Forest Entomology & Pathology Lab.
Department of Forestry
102 11 Avenue, East
Calgary, Alberta

McGUFFIN, Dr. CLAYTON
(Forest Biologist)
Forest Entomology & Pathology Lab.
Department of Forestry
102 11 Avenue, East
Calgary, Alberta

REID, ROBERT WILLIAM
(Forest Biologist)
Forest Entomology & Pathology Lab.
Department of Forestry
102 11 Avenue, East
Calgary, Alberta

SHEPHERD, R. F.
(Forest Biologist)
Forest Entomology & Pathology Lab.
Department of Forestry
102 11 Avenue, East
Calgary, Alberta

*STEVENSON, R. E.
(Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
102 11 Avenue, East
Calgary, Alberta

CANADA (Victoria and Vernon)

ATKINS, M. D.
(Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

CHAPMAN, Dr. JOHN A.
(Senior Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

CONDRASHOFF, SERGEI
(Associate Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Vernon, B. C.

DYER, E. D. A.
(Associate Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

EDWARD, Dr. D. K.
(Associate Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

*EVANS, D.
(Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

GRAHAM, Dr. KENNETH
(Professor of Forest Entomology)
Department of Zoology
Biological Sciences Building
University of British Columbia
Vancouver 8, B. C.

HARRIS, JOHN W. E.
(Associate Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

*HEDLIN, A. F.
(Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

KINGHORN, J. M.
(Senior Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

LEJEUNE, R. R.
(Officer-in-Charge)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

McKINNON, F. S.
(Chief Forester)
B. C. Forest Service
Parliament Buildings
Victoria, B. C.

McMULLEN, Dr. L. H.
(Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

MATHERS, W. G.
(Administrative Officer)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

MORRIS, Dr. O. N.
(Associate Insect Pathologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

RICHMOND, H. A.
(Consulting Forest Entomologist)
Lofthouse Road
R. R. #2
Nanaimo, B. C.

ROSS, Dr. D. A.
(Officer-in-Charge)
Forest Entomology Laboratory
Department of Forestry
Box 1030
Vernon, B. C.

*SILVER, Dr. G. T.
(Senior Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

SMITH, D. N.
(Associate Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
Victoria, B. C.

SPILSBURY, R. H.
(Forester-in-Charge)
Research Division
B. C. Forest Service
Victoria, B. C.

TOMCHENKO, SINOWY
1182 Kelowna Street
Vancouver, B. C.

WELLINGTON, Dr. W. G.
(Principal Forest Entomologist)
Forest Entomology & Pathology Lab.
Department of Forestry
409 Federal Building
Victoria, B. C.

CANADA (Ottawa)

FARSTAD, C. W.
(Director)
Plant Protection Division
K. W. Neatby Building
Ottawa, Ontario

FETTES, Dr. J. J.
(Head, Chemical Control Section)
Forest Entomology & Pathology Br.
Department of Forestry
Central Experimental Farm
K. W. Neatby Building
Ottawa, Ontario

GRAY, D. E.
(Assistant Director)
Forest Entomology & Pathology Branch
Department of Forestry
Room 226, Motor Building
238 Sparks Street
Ottawa, Ontario

McGUGAN, Dr. B. M.
(Assoc. Director-Forest Entomology)
Forest Entomology & Pathology Branch
Department of Forestry
Room 226, Motor Building
238 Sparks Street
Ottawa, Ontario

PREBBLE, Dr. M. L.
(Director)
Forest Entomology & Pathology Branch
Department of Forestry
Room 226, Motor Building
238 Sparks Street
Ottawa, Ontario

MEXICO

Ing. Humberto Moreno Noriega
Jefe del Dpto. de Sanidad Forestal
Direccion de Proteccion Forestal
Aquiles Serdan 28
Tercer Piso
Mexico 4, D. F.

Ing. Raul Rodriguez Lara
Seccion Entomologia
Instituto Nacional de
Investigaciones Forestales
Progresso No. 5
Coyaocan, D. F., Mexico

ENTOMOLOGISTS OUTSIDE GEOGRAPHICAL BOUNDARY OF W.F.I.W.C.

*COYNE, JACK
(Entomologist)
Southern Forest Experiment Station
P. O. Box 122
Gulfport, Mississippi

KNIGHT, Dr. FRED B.
(Associate Professor)
School of Natural Resources
Department of Forestry
University of Michigan
Ann Arbor, Michigan

*MERKEL, ED P.
(Entomologist)
Southeastern Forest Expt. Station
P. O. Box 3
Olustee, Florida

*THATCHER, ROBERT C.
(Entomologist)
Southern Forest Experiment Station
c/o Stephen F. Austin College
P. O. Box 345
Nacogdoches, Texas